WORLD METEOROLOGICAL ORGANIZATION

WMO SATELLITE REPORTS

APPLICATION OF SATELLITE TECHNOLOGY

ANNUAL PROGRESS REPORT

1990

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WMO/TD No. 431

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INTRODUCTION

The eighth session of the EC Panel of Experts on Satellites (1989) evaluated the format of the Progress Reports on the applications of satellite technology to meteorology and operational hydrology and recommended that the previous format was appropriate and should be continued. The panel stressed the importance of the timely distribution of this report.

The purpose of this publication is to make Members aware of the state of development in satellite applications, as well as the operational uses of satellite data, derived products and services in the meteorological and hydrological services in different countries.

This report includes the applications of satellite technology within three functional areas:

(1) Remote sensing of spectral radiation which can be converted into measurements for meteorological and operational hydrological applications (this includes the data and the derived products such as atmospheric soundings, sea surface temperature, satellite cloud wind, etc.);

(2) Collection of data from in-situ sensors (commonly referred to as the data collection system such as Service-Argos on the NOAA polar-orbiting satellites); and

(3) Transmission of satellite data through a direct broadcast mode (APT and High Resolution Picture Transmission (HRPT) on polar-orbiting satellites; WEFAX, and Low Resolution Facsimile (LRFAX); Primary Data Utilization Stations (PDUS), and Secondary Data Utilization Station (SDUS) on geostationary meteorological satellites).

The progress reports have the following major subdivisions:

PART I - A summary of the major highlights of research applications and operational changes;

PART II - Major research and development and applications of satellite data, derived products and services;

PART III - A description of techniques development and applications of satellite data, derived products and services;

PART IV - System for satellite applications in operational use in 1990

PART V - Plans for future operational systems for satellite applications to meteorology and operational hydrology

PART VI - Validation and verification of satellite data and derived products used in operations

PART VII - Other items (references, publications and names of scientists in charge, etc.)

The present report, the sixth in the series, contains contributions received in reponse to the request made in WMO circular letter S/MS/PUB of 8 February 1991. In that letter, Members were requested to provide input for this report and where possible on diskette to allow electronic editing. This has allowed a more uniform display of Members' activities.

SUMMARY

This set of reports for 1990 from 29 Members and EUMETSAT shows a continued development of satellite data applications to various fields of meteorology and operational hydrology.

Satellite data are continuing to be used operationally for monitoring tropical cyclones, severe meso-scale storms, floods and forest fires, and for derivation of the basic physical parameters of both the atmosphere, such as wind, temperature and moisture, and the surface, such as sea surface temperature, vegetation, ice and snow cover, sea ice, ocean states and albedo. Convective rainfall, monthly river run-off and water balance are successfully determined by using more sophisticated satellite retrieval techniques. These parameters are widely applied to diagnostics, nowcasting, numerical weather prediction and climate studies.

The number of meteorological satellite ground stations continue to increase and some are being upgraded to obtain the high resolution satellite direct broadcast data. Satellite data are handled in a digital format at the high resolution stations, most of which carry on some operations to derive quantitative information from the radiances. This information is being increasingly used as input data for numerical weather-prediction models. Atmospheric sounding data and cloud-wind vectors are input in the objective analysis scheme. Humidity estimates are made using satellite image data.

Satellite-based telecommunication continues to increase for operational use among WMO Members. Satellite data collection provides a valuable source of in-situ observation data from isolated meteorological and hydrological stations and from ships, buoys and aircraft. Such data from remote regions also offer ground truth information concerning various meteorological and hydrological parameters for validating information derived from satellite remote sensing.

The individual Member reports contain a wealth of current infomation. In particular, the bibliography at the end of each chapter should be an excellent reference for those Members seeking a more indepth explanation.

ARGENTINA

Servicio Meteorológico Nacional (SMN)

PART I Summary of the major highlights of research applications and operational changes

1.1 There was fairly good APT data reception from TIROS/NOAA satellites as well as METEOR and WEFAX from GOES.

1.2 Since May 1987, no data have been received from GOES due to the fact that the receiving system is unable to receive data from this satellite in the new format.

1.3 Data from some selected platforms are currently received.

PART II Major research and development in the applications of satellite data, derived products and services

2.1 A study on surveying of crop and pasture areas using the Vegetation Index from NOAA images is presently being carried out.

2.2 A study on precipitation estimation derived from cloud convective system identification using satellite images has been delayed until GOES data can be received.

PART III A description of techniques development in the applications of satellite data, derived products and services

3.1 APT, WEFAX and HRPT images are currently being used in weather analysis and forecasting activities at the Buenos Aires Regional/Specialized Meteorological Center and at other local forecasting offices.

3.2 A nephanalysis covering the area from 20°S to 60°S and 30°W to 100°W is transmitted (twice a day) by the Buenos Aires Regional/Specialized Meteorological Center.

3.3 Since January 1990, a monthly report concerning the evolution of crops and pastures in Pampa Humeda zone of Argentina using the Vegetation Index from NOAA images has been issued by the National Meteorological Service.

3.4 At present, the Buenos Aires HRPT station receives AVHRR, TOVS and DCS data from TIROS/NOAA satellites as well as DCP from GOES.

3.5 Archives of TIROS/NOAA satellite images have been established as follows:

- From July 1984 to October 1985, with the assistance of the University of Miami, on digital tapes of 6250 bpi, covering the Argentina Atlantic area.
- Since October 1985, data have been stored on magnetic tapes without processing.

PART IV System for satellite applications in current operational use

4. Same as described in 1986.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. Plans include the attainment of temperature and humidity profiles from radiance inversion.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6. None at the present time.

PART VII Other items (references, publications and names of scientists in charge, etc.)

7.1 Publications:

Brizuela A.B., Pujol G.C., Cababié R.J.
"Evaluation of crop development using vegetation index and meteorological data", Proceedings of IV Latin American Meeting on Remote Sensing -Brasil 1986.

Paruelo J., Aguiar M., Pujol G.C., Galluscio R., León R.
"Vegetation heterogeneity on arid and semiarid Patagonia: an analysis using AVHRR/NOAA satellite imagery", Paper presented at the International Symposium toward a Quantitative Phytogeography. Rome, Italy. Accepted for publication in Annali di Botanico. Roma 1988.

7.2 Correspondence should be addressed to:

Servicio Meteorologico Nacional
25 de Mayo 658
(1002) Buenos Aires
Argentina

AUSTRALIA

Bureau of Meteorology

PART 1 Summary of major highlights of research applications and operational changes

1.1 During 1990, the operational satellite reception and processing systems operated by the Australian Bureau of Meteorology generally performed extremely well. Data and products from GMS, NOAA, FY-1b and GOES-WEST satellites were used. The Stretched-VISSR MDUS GMS reception station in Melbourne remains the main source of operational satellite imagery, and is backed up by SDUSs in Melbourne and Darwin. The Australian network of HRPT S-band reception stations has been expanded from the existing two stations (Melbourne, Perth) to a third (Casey in Antarctica) and a fourth station (Darwin) which will be operational later in 1991. Work has commenced on a variety of applications of GMS and NOAA AVHRR data, and NOAA TOVS data is being processed with a statistical and a one-step physical retrieval scheme. The main tool for interactive processing and display of satellite data continues to be the Australian Region McIDAS (ARM).

1.2 The data collection systems on GMS and NOAA were extremely important for timely relay of data from remote observing platforms. The GMS DCP capability was used for about twenty AWSs, while reports from about 150 southern-hemisphere drifting buoys, including some AWSs, relayed via the Service Argos system on NOAA satellites, were received regularly over the GTS.

1.3 The Personal Computer version of ARM, (called PC-ARM) an interactive graphics processing and analysis system, was introduced into operational forecasting centres. It provides meteorologists with an integrated data base including all satellite data, conventional observations, and NWP model data from the WMC Melbourne. The system is also used in research and training areas.

1.4 In terms of research and development, further progress was made with trial assimilation of physical TOVS retrievals into the Bureau's main Australian region NWP model, called RASP (Regional Assimilation and Prognosis Scheme). Total ozone estimates from TOVS data were being retrieved, and further testing of Cloud Drift Winds (CDWs), derived from GMS half-hourly images using ARM was undertaken. Other R & D work took place on solar radiation estimates from GMS data, cloud climatology, sea ice, Normalised Difference Vegetation Index (NDVI) estimates from AVHRR data, and on two Bureau Announcements of Opportunity with the NASA Earth Observation System (EOS) Polar Platforms.

1.5 Overall, 1990 has been a year of consolidation and expansion of the Australian Bureau of Meteorology's reception and processing network, as well as its dissemination and display capabilities for satellite data. Continuing work is focusing on applications of satellite data, development of X-band stations, archival, and R & D for utilisation of future types of satellite data.

PART II Major research and development applications of satellite data, derived products and services

2.1 An operational version of the "one step" TOVS physical retrieval scheme has been run in real time on ARM for evaluation and verification. The processed TOVS data were assimilated into the RASP model to assess the impact of the satellite data - first results are most encouraging. The retrieval scheme generates temperature, moisture, skin temperature, cloud parameters (height, effective amount, etc) as well as total ozone amount. A verification and optimisation program on the ozone retrieval algorithm is continuing using Dobson spectrophotometer and ozone sonde data.

2.2 A Cloud Drift Wind (CDW) package on ARM was run operationally four times a day (05, 11, 17 and 23 UTC) using GMS imagery. The CDW system algorithms and quality control methodology allow fully automatic generation of real time CDWs over most of the southern hemisphere portion of the GMS disk. The CDWs are being assimilated into the RASP model on a trial basis. The verification involves comparison of CDWs with radiosonde data, and comparison of RASP forecasts which utilise CDW data with operational RASP products which do not use CDW data. The verification procedures are being changed to conform to strict CGMS (i.e. international) standards. The Australian Bureau of Meteorology's CDW work is contributing to a collaborative program with the Japan Meteorological Agency involving intercomparison of CDWs.

2.3 A comprehensive satellite and thermodynamic analysis of tropical cyclone Hilda was completed in the Bureau of Meteorology Research Centre and submitted for publication. A program was commenced to build up a cloud climatology over the Australian Region. Solar radiation estimates (radiative fluxes) from GMS data were being derived on an hourly basis, operationally.

2.4 Further research was undertaken on two Announcements of Opportunity (AOs) with the NASA EOS. One is an interdisciplinary proposal titled "The processing, evaluation, and impact on NWP of AIRS, HMMR, MODIS and LAWS data in the tropics and southern hemisphere", with Principal Investigator Dr John Le Marshall; the other AO is titled "The processing and validation of AIRS data and its impact on mesoscale analysis and prediction." The latter involves Dr Le Marshall as a member of the Atmospheric InfraRed Sounder (AIRS) team of scientists. Synthetic AIRS data are being generated using both line by line and parameterised transmittance calculations. These synthetic data will be used to calculate temperature and moisture profiles over the Australian region and to assess their impact on NWP analysis and prediction.

PART III A description of techniques development and applications of satellite data, derived products and services

3.1 Most work in this area was carried out using ARM, and includes basic improvements to the system's capability to process and manipulate satellite data. For example, mosaics of NOAA imagery, remapped to a selected projection, are available in real time. Full capabilities involving looping, enhancements, overlaying, remapping, navigation and coastlines, etc were used operationally to improve the effectiveness of satellite data applications to forecasting and warning.

3.2 Development work with AVHRR data continued including refinement of a set of algorithms for estimating Antarctic sea ice concentration, and development of low cloud detection algorithms. Preliminary versions of two

algorithms for deriving clear column precipitable water from AVHRR split window measurements were developed and tested.

3.3 An extensive project to derive NDVIs over the Australian region using NOAA AVHRR was commenced with a view to providing regular products for use in fire weather forecasting and in climate monitoring.

3.4 GMS imagery was analysed using three different techniques (Arkin threshold; simplified Griffith-Woodley technique; convective stratiform technique) to estimate rainfall as part of an algorithm intercomparison program for the Global Precipitation Climatology Project. In addition, estimation of precipitation using satellite data is a component of a project in which the Bureau of Meteorology is currently involved with the US National Weather Service. Progress in this area is expected during 1991.

3.5 A programme to improve the navigation of real time satellite images using automatic landmark recognition was commenced, and is continuing as part of a collaborative project with the State Meteorological Administration of China.

PART IV System for satellite applications in current operational use

Imagery

4.1 The MDUS in Melbourne receives full disk visible and infrared imagery from GMS on an hourly basis, and half-hourly four times per day. The data are ingested directly into the Bureau's Fujitsu M382 mainframe computer system, on which all processing is done using ARM software. Calibrated and navigated imagery is disseminated in real time to service outlets throughout Australia (the World Meteorological Centre, the National Meteorological Centre, 7 Regional Offices and 29 Weather Services Offices). There are SDUSs in Melbourne and Darwin as backup to the Melbourne MDUS.

4.2 HRPT S-band stations in Melbourne and Perth are used to receive NOAA AVHRR, TOVS and DCP data. Melbourne data is ingested into the Fujitsu M382 and processed using ARM. Perth data is ingested and processed locally on IBM PCs. An HRPT S-Band station was established in Casey (Antarctica) at the end of 1990 and currently operates the same as the Perth station.

4.3 APT receivers are available in four Regional Offices and are used at Antarctic bases at Mawson, Davis and Casey and on Antarctic vessels, to supply forecasters with NOAA or METEOR imagery.

4.4 WEFAX transmissions from GOES-WEST are received via a reception station in Brisbane and these provide NOAA southern hemisphere imagery for WMC Melbourne operations.

TOVS

4.5 TOVS data (in TIP form) are acquired directly by reception of HRPT broadcasts, and are processed operationally using a statistical retrieval scheme and on an experimental basis using a physical retrieval scheme, as described earlier. With the statistical scheme, the data are processed to about 70 km resolution within about 15 minutes of orbit time. The routine display consists of analysed fields of 1000-500 hPa thickness, 250 hPa

geopotential height, and superimposed geostrophic wind vectors. Displays in other forms are available on PC-ARM terminals, including physical TOVS retrievals. The physical retrieval scheme provides some significant improvements over the statistical scheme, including better moisture determinations.

4.6 TOVS data from WMC Washington, processed by NOAA/NESDIS is received via the GTS, and is used operationally.

Operational satellite display systems

4.7 The main platform for operational display and analysis of satellite data and products is PC-ARM. It provides meteorologists with an integrated data base (as described above) and a comprehensive suite of applications programs to allow such things as satellite orbit display, enhancements, contrast stretching, looping, overlays, etc. PC-ARM is used in WMC Melbourne, seven Regional Forecasting Centres, severe weather forecasting areas, the Bureau's Training Centre, and many other development areas. Full resolution GMS S-VISSR and NOAA AVHRR imagery, plus TOVS and DCP data are available in real time on PC-ARM, together with complementary data.

4.8 Two other less sophisticated but highly effective systems complement PC-ARM in terms of satellite data display, and are called Digital Satellite Broadcast (DSB) and Digital Facsimile (DIFACS). DSB is used in Regional Forecasting Centres to display GMS imagery with a 256-level greyscale and selectable colour enhancements and looping. DIFACS is being progressively installed in all operational offices and is the replacement for the Bureau's aging analogue fax network. It provides display and hard copy of NWP charts, and GMS imagery at reduced resolution.

SATOB data

4.9 CDWs from GMS, GOES and METEOSAT, received via the GTS, are routinely used in WMC Melbourne analyses. The GMS winds are particularly useful in analyses over otherwise data sparse ocean areas around Australia, and as input for the automated tropical analysis scheme run by Darwin RMC.

DCP data

4.10 Drifting buoy data are received over the GTS from the Service Argos DCP system on NOAA satellites, and provide, inter alia, vital surface pressure information for WMO hemispheric and Australian region analyses. DCP data are also stripped out of the TIP data received in real time from stations in the Australian national HRPT reception network, and are used in forecasting areas including WMC Melbourne.

Hydrological data

4.11 Operational Flood Warning Centres have now been established in all States and the Northern Territory of Australia. These centres will provide flood warning services to response groups within their respective regions. Preliminary progress has been achieved in the use of satellites for the detection of flood movement in large inland river systems (April 1990 flooding), for collection of field data (Inmarsat-C) and in the estimation of precipitation.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 During the Antarctic summer of 1990/91, the HRPT S-band reception station at Casey was installed and commissioned, and is now operational. The station is a joint initiative of the Bureau of Meteorology and the Antarctic Division of the Department of the Arts, Sport, the Environment, Tourism and Territories of the Australian Government. By late 1991 another HRPT station will be operational at Darwin, and this will complete the plan for a national HRPT network. DCP installations are continuing at remote locations, and drifting buoys are being deployed, for data relay via satellite.

5.2 As part of a Working Arrangement with China's State Meteorological Administration, the Australian Bureau of Meteorology is designing and constructing a Turn Around Ranging Station in Melbourne to support China's planned geostationary meteorological satellite FY-2. A data reception and processing station will be developed in 1992-93.

5.3 The Australian Bureau of Meteorology is a member of a consortium which is building an X-band reception and processing station in Hobart for ESA's oceanographic satellite, ERS-1.

5.4 Strong emphasis is being on the development of applications and value-added products from existing satellite data, especially NOAA AVHRR, GMS and TOVS. Much attention is being focused on AVHRR for SST, sea ice, low cloud, volcanic ash, NDVI, and flood monitoring applications. CDWs from GMS are being refined and it is planned to eventually distribute these over the GTS.

PART VI Validation and verification of satellite data and derived products used in operations

6. Calibration data from NOAA/NESDIS and from JMA are used respectively for NOAA and GMS imagery. Ground truth and NWP output are used to monitor and verify a variety of satellite products including TOVS soundings, surface temperatures, rainfall estimates, CDWs NDVIs and SSTs. Nearly all data are archived.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

7.1 Lead scientists and staff for enquiries are as follows:

- satellite systems, reception, processing, display systems, applications, and operational products (Mr Bruce Neal);
- research and development in remote sensing (Dr John Le Marshall);
- training aspects in satellite meteorology (Mr John Mottram);
- operational use of satellite products in WMC Melbourne and National Meteorological centre (Dr Geoff Love).

7.2 For policy issues and for information on research projects and lead scientists at related Australian institutions, the contact is Dr Doug Gauntlett, Deputy Director (Research and Systems).

7.3 All the above scientists may be contacted at the Australian Bureau of Meteorology, GPO Box 1289K, Melbourne, Victoria, Australia 3001.

7.4 Some of the Bureau's more recent satellite and related publications are as follows:

Griersmith, D., and Zillman, J.W. 1989 Satellite Meteorology, Search, 20, no 1, 7-15.

Holland, G., and Ebert, E. 1990 Observations of record cold cloud top temperatures in tropical cyclone Hilda (1990), Monthly Weather Review (in press).

Le Marshall, J.F., Davidson, R.F, Willmott, M.C., and Powers, P.E. 1989, A physically based operational atmospheric sounding system for TOVS data in the Australian region, Australian Meteorological Magazine, 37, 193-199.

Nunez, M. 1990 Satellite estimation of regional solar energy statistics for Australian capital cities. Meteorological Study 39, Bureau of Meteorology, Melbourne, 314pp.

Puri, K. 1990 The use of satellite data as proxy data for moisture and diabatic heating in data assimilation. WMO Gewex Workshop on temperature and humidity profile retrievals, Washington DC, 23-26 October 1990.

Zillman, J.W., Griersmith, D., Le Marshall, J., and Gauntlett, D. 1990, Remote sensing applications in the Australian Bureau of Meteorology, International Journal of Remote Sensing, 11, no. 11, 1979-1997.

AUSTRIA

Central Institute of Meteorology and Geodynamics

PART I Summary of major highlights of research applications and operational changes

1.1 A system has been developed to process satellite images from archive on a workstation in respect to different research purposes. Processing includes false colouring, transformation to a (lambda,sin(phi))-grid, Lambert correction of VIS-images and superposing of ECMWF parameter fields as well as precipitation values and fields. Some statistic programmes have been developed for determination of precipitation areas and amounts from the images.

1.2 Research topics have been:

- Cloudiness and precipitation in connection with jet streaks
- Cloud systems in connection with warm air advection
- Precipitation areas in connection with the path of PVA maxima seen in satellite images.

1.3 For the operational service, a PDUS device has been installed.

PART II Major research and development and applications of satellite data, derived products and services

2.1. The work on the derivation of conceptual models of jet streak cloudiness has been continued. The different forms of modification of frontal cloudiness and precipitation have been taken into account.
(Veronika Zwatz-Meise, and Günther Mahringer)

2.2 Typical cloud configurations in connection with warm air advection have been investigated by different means of image processing as well as by meteorological parameters on isobaric and isentropic surfaces. Conceptual models for different forms of classical and non-classical warm fronts and non-frontal cloudiness have been developed.
(Veronika Zwatz-Meise, Gerd Ragette, Felix Hufnagl)

2.3 PVA maxima and their path from ECMWF analyses have been investigated by means of image processing. These areas are connected with vertically increased cloudiness and increased precipitation events and amounts. The ECMWF model underestimates precipitation there. Satellite images can be used to confirm the model and to track the areas of PVA maxima.
(Veronika Zwatz-Meise, Karin Bendl, Kurt Zimmermann)

PART III A description of techniques development and applications of satellite data, derived products and services

3.1 A software package has been developed to process satellite images (at the moment only from archive) on a workstation. The images are transformed into a (lambda, sin(phi))-grid. VIS images are corrected with respect to sun angle and false colouring is possible. All parameter fields from ECMWF used at

the Central Institute are transformed into the same grid and superimposed on the image. This is the case for precipitation events and amounts, too. Statistical programmes are used to develop a special VIS-IR method for precipitation recognition from the images. For this purpose only an area of West and Central Europe is used.

(Franz Rubel, Johann Stockinger, Veronika Zwatz-Meise)

PART IV System for satellite applications in current operational use

4.1 As in the years before an SDUS device has been used in 1990 but a PDUS device is being installed.

4.2 As in the years before, Meteosat satellite images are used together with model output parameters and in connection with conceptual models. Identification and tracking of precipitation areas by false colour methods have been tested. Satellite images are received half hourly or hourly in the operational service and are archived in three hours intervals for research purposes; for test series also half hourly images are archived.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

- Superposition of diverse parameter fields and cross sections on satellite images;
- Automatic derivation of conveyor belts on isentropic surfaces and superposition on satellite images;
- Automatic and semi-automatic nowcasting methods in respect to precipitation;
- Combination of satellite and radar images.

PART VI Validation and verification of satellite data and derived products used in operations

6.1 No investigations in this topic have been carried out.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

Zwatz-Meise V. and G.Mahringer, 1990: SATMOD: An Interactive System Combining Satellite Images and Model Output Parameters. Wea. and Forecasting, Vol.5,no.2.

Zwatz-Meise V., and F.Hufnagl, 1990: Some Results about the Relation between an objective Front Parameter and Cloud Bands in Satellite Images and its Connection to Classical Cold Front Models. Meteorol. Atmos. Phys.,42,77-89.

Zwatz-Meise V. 1990: Very Short Range Forecasting Frontal and Non-Convective Weather. Proceedings of the workshop of the use of satellite data in nowcasting and very short range forecasting. EUMETSAT EUM P 07.

Stockinger J., 1990: Quantitative Methoden zur Bestimmung von Niederschlagsfeldern aus Satellitendaten und Bodenmessungen und Anwendung einer statistischen Methode. Diplomarbeit an der naturwissenschaftlichen Fakultat der Universitat Wien.

BELGIUM

Royal Meteorological Institute

PART I Summary of the major highlights of research applications and operational changes

1.1 During the year 1990, the computer capacities of the meteorological institute have been renewed with the replacement of the former mainframe by a new UNIX based system with an Ethernet network.

1.2 Workstations have been purchased and software has been developed to improve satellite image acquisition and processing.

1.3 Meteosat-SDUS, NOAA-APT and radar images have continued to be routinely used as a tool for analysis and weather forecasting.

PART IV System for satellite applications in current operational use

4. Real-time acquisition and processing of satellite and radar images are made using PCs and UNIX workstations. Software is based on international standards (XWindows, GKS, Motif, ...).
(R. Heylen).

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 It is intended to purchase hardware and to develop software for real-time acquisition and processing of Meteosat-PDUS and NOAA-AVHRR images.
(R. Heylen).

5.2 Research and development will start in 1991 to estimate short and longwave surface radiation and evapotranspiration by clear sky from Meteosat-PDUS images.
(F. Gellens-Meulenberghs).

CANADA

Atmospheric Environment Service .

PART I Summary of the major highlights of research applications and operational changes

1.1 Research and development on applications of satellite data was carried out in three main areas: use of satellite data in regional weather centres, assimilation of satellite data into numerical weather prediction models, and use of satellite data in hydrometeorological applications. Use of satellite image analysis facilities was expanded in regional weather centres, and a number of new satellite data applications became operational at the Canadian Meteorological Centre (CMC). The major change in operational systems currently planned is the implementation of a distributed system for reception of GOES-NEXT data.

PART II Major research and development in the applications of satellite data, derived products and services

Explosive Cyclogenesis in the Eastern Pacific

2.1 A technique for predicting explosive cyclogenesis has been developed at the Pacific Weather Centre based on a detailed study of 111 storms over the eastern Pacific during the 1986-87 and 1987-88 storm seasons (McLennan et.al. 1989). The first step of the procedure is to examine the flow pattern based on Weldon's classification. When a flow pattern conducive to explosive cyclogenesis is identified, 22 factors influencing development potential are evaluated. Hourly GOES IR and water vapour images are utilized to a great extent, along with visible images when available. In addition, TOVS data from polar orbiters is used for generation of thickness patterns and gradients. The factor values are input to four statistical procedures (MDA, REEP, CART, and MLR), and the final decision is based on the output of all four procedures. Considerable success was achieved in the dependent sample, with more than 90% of storms in the sample set being correctly classified. PROBE "Procedure for Bomb Evaluation" has been in operational use for three years. It has been successful in a number of cases in which numerical weather prediction models failed to predict explosive development. A paper including verification statistics is planned for the coming year. Work is also planned on the use of artificial intelligence techniques for evaluation of the development potential factors. (N.McLennan and L.Neil, Pacific Weather Centre)

Assimilation of Satellite Data into Numerical Weather Prediction Models

2.2 Work is continuing on the use of raw cloudy radiances in the CMC analysis following Eyre's non-linear optimal estimation approach. Further results will be presented at the Sixth International TOVS Study Conference in May 1991. The recent implementation of a global data assimilation cycle at CMC has resulted in increased emphasis on effective use of SATEMS. The current method of assimilating SATEM retrievals into the Canadian Meteorological Centre forecast cycle is being modified to assimilate the soundings as thicknesses over fairly thick layers, following the method developed at ECMWF. Development of a system for estimation of humidity profiles from GOES and Meteosat imagery is under way in co-operation with the Canadian

Meteorological Centre. It is intended to expand this system to produce satellite precipitation estimates and to provide data for diabatic initialization of CMC models. The project will build on previous work on satellite estimation of precipitation and other parameters (Garand 1989a,b; King et.al., 1989; King 1990) and on diabatic initialization (Turpeinin et.al., 1990; Turpeinin, 1990; Turpeinin and Garand, 1990). A study aimed at improving the impact of ERS-1 scatterometer winds in the CMC analysis cycle has been initiated. Preliminary results (using simulated data) will be presented at the 1991 AMS NWP conference. (J.D.Steenbergen, Meteorological Services Research Branch)

Use of Satellite Scatterometer winds for Driving an Ocean Wave Model

2.3 The utility of SEASAT A Satellite Scatterometer (SASS) winds for driving a spectral ocean wave model was studied. The SASS winds were integrated with conventional ship winds using a successive correction analysis scheme, modified to account for variable data density, data quality, and the application of an elliptical weighting function. The study demonstrated that the integration of SASS data provided improved wind inputs for validating wave models in a hindcast mode. (R.Lalbeharry, M.L.Khandekar, S.Peteherych, Meteorological Services Research Branch)

BOREAS - Boreal Ecosystem Atmosphere Study

2.4 BOREAS is a co-operative Canadian/NASA field and analysis study involving elements of land surface climatology, tropospheric chemistry and terrestrial ecology; remote sensing will play a strong integrating role. The goal of the study is to understand the interactions between the boreal forest biome and the atmosphere in order to clarify their roles in global/climate change. BOREAS is currently in the planning stage. During 1990 a Science Plan was prepared and distributed for comment. Two 20 x 20 km field study sites were also chosen in 1990, located near the northern and southern limits of the boreal forest in Canada. Current planning views the study sites as long term observatories suitable for integrated monitoring of environmental change. (B.E. Goodison, Climate Research Branch, is a member of the BOREAS Science Steering Committee)

Use of Satellite Data in Hydrometeorological Models

2.5 Research is being carried out into the use of satellite data in hydrometeorological models in western Canada. Three models are being developed and tested for prairie and mountain watersheds. A lumped model has been completed and a distributed model, Hydrotel, is still under a development contract between the Department of Energy, Mines and Resources, Environment Canada and the University of Quebec. A third, semi-distributed model using satellite-derived land classifications, is being developed in co-operation with Manitoba Hydro and the University of Waterloo. Work has concentrated on using Landsat data for land use classification and NOAA AVHRR data for snow-cover estimation in the model. Use of a combination of DMSP SSM/I brightness temperature and NOAA infrared data for estimating snow water equivalent is also being investigated. The use of satellite data in this way will enable the model to be transferred to different basins without the need for re-calibration. Copies of this model have been requested by government agencies and consulting companies in Canada, the U.S.A., Europe and Asia.

2.6 In February, 1990, a workshop on Applications of Remote Sensing in Hydrology was held in Saskatoon. Over 60 scientists from Canada, the U.S.A., Europe and Asia participated. There are a limited number of copies of the 386 page proceedings available. (G. Kite, Hydrometeorological Processes Research Division, Saskatoon).

Snowpack Monitoring for Canadian Watersheds Using NIMBUS 7 SMMR Algorithms

2.7 The monitoring of snowpack by microwave satellite is being tested in a study of nineteen watersheds across Canada. The basins are located in eleven regions within the Mountain, Agricultural and Boreal forest zones. The satellite observations are an eight year record of archived Nimbus 7 SMMR images, which are compared with snow water-equivalent measurements at 94 snow courses. The test watersheds are unregulated basins with less than 7% surface water coverage and with basin areas between 2500 and 25000 square kilometres.

2.8 The most significant microwave bands appear to be 18 GHz and 37 Ghz (either polarization). However, some bands are better in particular regions: e.g., in the Southern Cordillera the 18 Ghz correlations are best; while in Agricultural regions (Plains and Southern Ontario) the 37 Ghz and spectral difference bands are the most significant. Algorithm parameters (i.e., slope & intercept in the snowpack-microwave relation for a particular band) are significantly correlated with measured forest biomass in each basin. Definition of this algorithm dependence is currently under investigation, so that snowpack can be monitored by satellite in uninstrumented watersheds. (A.Wankiewicz, National Hydrology Research Institute, Saskatoon)

Canadian Prairies Snowcover Monitoring using SSM/I Data

2.9 Over the past several years, algorithms have been developed and tested for the determination of snow water equivalent (SWE) from passive microwave satellite data for the Canadian Prairie region of North America. Starting with the 1988/89 winter season, near real-time SWE maps have been produced on a weekly basis using data from the Special Sensor Microwave Imager (SSM/I) on board the U.S. Defense Meteorological Satellite Programme (DMSP) F-8 satellite. These maps are distributed by facsimile to co-operating meteorological and water resource agencies located in the Canadian Prairie region. The acquisition of the SSM/I data and processing into the SWE map product are the responsibility of a private company under contract. The current operational SWE algorithm is only valid for the non-vegetated open prairie regions. In forest-covered areas, the algorithm produces underestimated values of SWE. Research is currently being conducted to derive an algorithm, or series of algorithms, which will produce valid SWE information for the forested areas of the Canadian Prairie region and the Northwest Territories. (B.E. Goodison and A.E. Walker, Climate Research Branch).

PART III A description of techniques development and applications of satellite data, derived products and services

Satellite Image Analysis Systems

3.1 An image analysis system for AVHRR data has been developed in the Western Region and is in operational use at the Arctic and Alberta Weather Centres. The package operates using X-Windows under the UNIX operating system

and includes features such as interactive colour table control, display of multi-spectral images, radiance to brightness temperature conversion, and geographic overlays. Specialized enhancements are used for thunderstorm cloud-top temperature structure, sea-surface temperatures, discrimination of cloud over ice, and forest fire discrimination.

3.2 Software has been developed at CMC to display and enhance satellite images on graphics workstations. Imagery can be combined with fields of conventional data and plotted observations. The system also animates GOES images.

Arctic Climate Monitoring Using Passive Microwave and AVHRR Data

3.3 Passive microwave data (SMMR and SSM/I) are being used for the detection of regional sea ice trends in Hudson Bay, Eastern Canadian Seaboard and the Canadian Beaufort Sea. The work is aimed at climate monitoring and improving monthly and seasonal climate forecasts. Near real-time SSM/I data are obtained from CMC and processed to produce ice monitoring products such as regional sea ice anomaly charts and lake ice breakup and freeze-up information. Historical data is also obtained on CD-ROMs from the National Snow and Ice Data Centre in the US. (T. Agnew, Arctic Adaptation Division, Canadian Climate Centre).

Integration of Conventional and Remotely Sensed Observations of Climate Parameters

3.4 CLI-GRID, a project to develop and evaluate techniques for objectively integrating conventional and remotely sensed observations of climate parameters, continued to progress in 1990. In co-operation with the Meteorological Services Research Branch, GMS data for the Japan area were used to make satellite estimates of rainfall for the WMO/WCRP Global Precipitation Climatology Algorithm Intercomparison Project. Estimates from three techniques (Garand, 1989; King et.al., 1989; Hogg, 1990) were compared with radar and gauge estimates of rainfall provided by the Japanese Meteorological Service. A technique to combine gauge and satellite estimates of rainfall was evaluated (Hogg, 1990). The technique uses statistical optimal interpolation to interpolate differences between satellite and gauge estimates and create a difference/correction field. A method for estimating evapotranspiration using satellite data underwent preliminary evaluation prior to its use in a more extensive field test on the Canadian prairie during 1991. (W.D. Hogg, Data Integration Division, Canadian Climate Centre).

PART IV Systems for satellite applications in current operational use

4.1 The AES operates three GOES direct readout stations in Vancouver, Toronto, and Montreal (CMC); and two HRPT stations in Toronto and Edmonton. These stations distribute products to forecast and briefing offices via a broadcast communications system. The Edmonton HRPT station and the GOES facilities in Vancouver and Montreal produce and transmit a number of products in polar stereographic projection. The AES also operates several HRPT stations in the Yukon and Northwest Territories.

4.2 Data Collection Platform (DCP) data from buoys in the Arctic and Pacific Oceans are received and processed in Edmonton. These are formatted in DRIBU code and placed on GTS circuits. DCP data are also received and processed in Toronto.

4.3 CMC is in the process of installing a Meteosat receiving station. This station will receive the Meteosat data relayed on GOES 6 and will be capable of receiving the data directly when Meteosat 4 is moved to 50 degrees West.

4.4 An algorithm for sea surface temperature retrieval from GOES data, originally developed at the University of Wisconsin, is run operationally at the CMC. The GOES SST retrievals as well as NOAA 11 and METEOSAT SST retrievals received over the GTS are used by the operational Sea Surface Temperature analysis.

4.5 The CMC receives SSM/I brightness temperature files from the U.S. Navy in Monterey in near real time. Charts of precipitation rate and surface wind speed over the oceans, derived from the SSM/I temperatures, are transmitted to the forecast offices on a regular basis. An ice cover analysis using SSM/I ice retrievals has been developed and is running in parallel. Derived ice data are provided to the Canadian Ice Centre and the Arctic Climatology Group in Downsview. The algorithms used to process the SSM/I data were developed at the Institute for Space and Terrestrial Science at York University.

4.6 Since 1980, the Climate Adaptation Branch of the Canadian Climate Centre has carried on operational surface water temperature monitoring on the Great Lakes and Bay of Fundy from NOAA polar-orbiting satellite Channel 4 AVHRR (9.5 to 11.5 micrometre) data. Surface water temperature maps of the Great Lakes and Bay of Fundy are distributed to regional weather offices of the Atmospheric Environment Service and to other organizations concerned with water resource management.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 The AES is preparing to receive, process and distribute data from the next generation of GOES satellites. The GOES-90 project will replace the current centralized GOES reception and processing systems with a more distributed system for GOES-NEXT. Ground stations will be installed on-site for the large data volume users in most forecast offices. These stations will connect to local area networks where forecaster workstations will have access to GOES data sets for interactive processing and integration with other data. A broadcast telecommunications system will be used to provide data in digital format to other users in weather presentation offices. (B.Green, GOES-90 Project Manager)

PART VII Other items (references, publications and the names of scientists in charge, etc.)

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CANADA

Conservation and Protection, Water Resources Branch
Inland Waters Directorate

Hydrology

HYDROTEL - Hydrologic Modelling System

1. Over the past decade, various studies have concluded that the potential benefits of spatial remotely-sensed data cannot be realized unless hydrologic models are designed to make direct use of such data. In 1988, under contract to the Government of Canada, the Institut National pour la Recherche Scientifique-Eau (INRS-Eau) of the University of Quebec commenced development of a flexible hydrologic modelling system (HYDROTEL) capable of making effective use of satellite and other remotely-sensed data. Designed for use on low-cost micro-computers, HYDROTEL features a modular structure with distributed (square-grid) input, and interfaces with modern image analysis and geographic information systems. The flexibility of HYDROTEL allows the user a choice of algorithms for modelling a particular component of the hydrologic cycle. The user may select the algorithms that suit the needs and data availability of the modelling application.

2. The HYDROTEL system consists of three separate computer programmes: the hydrologic model (HYDROTEL), an image analysis software (IMATEL), and a basin information system (PHYSITEL) for processing digital elevation and land-cover data and establishing the square-grid structure. The latest versions of HYDROTEL are being tested in three Canadian Basins: the Kootenay (British Colombia), the Grand (Ontario), and the Clifton (Quebec). A major application is being planned for the Saint John River Basin in 1991.

Direct Readout Ground Stations

3. Out of some three thousand hydrometric active gauging stations that Water Survey of Canada operates, about 400 are equipped with Data Collection Platforms (DCP) which transmit environmental data via GOES satellites. The gauging stations containing DCPs are usually located in remote northern areas accessible by helicopters or aeroplanes equipped with floats or skis. Approximately half of the DCPs transmit data via GOES West and half via GOES East.

4. Environment, Canada's Atmospheric Environment Service and Water Survey of Canada operates three Sutron Direct Readout Ground Stations (DRGS). One is located in Vancouver and monitors GOES West located at 135 degrees west. Another one is located in Toronto and monitors GOES East located at 75 degrees west. The third DRGS is located near Ottawa and serves as backup to the other sites.

5. The environmental data collected include: water level, velocity of water, discharge, water temperature, air temperature, temperature inside shelter, ice thickness, sensors indicating presence or absence of ice, wind speed and direction, precipitation, air pressure, and various sensors indicating the performance of instruments.

6. The three DRGSs are connected via computer network and the data from them can be sent to any computer in Canada connected to that network.

CHINA

Satellite Meteorological Centre

State Meteorological Administration

PART I Summary of the major highlights of research applications and operational changes

1.1 China successfully launched its second polar-orbiting meteorological satellite FY-1B on September 3, 1990. The satellite was accurately sent into the expected sun synchronous orbit and began to send out HRPT and APT data soon after.

1.2 The Advanced Very High Resolution Radiometer (AVHRR) on board the satellite has five channels with the subpoint resolution of 1.1 km. The bands of the channels are: 0.58--0.68 μm, 0.725--1.1 μm, 0.48--0.53 μm, 0.53--0.58 μm, 10.5--12.5 μm. The received visible and infrared cloud images of the satellite are quite clear.

PART II Major research and development in the applications of satellite data, derived products and services

2.1 The Satellite Meteorology Center (SMC) of the State Meteorological Administration of China receives the stretched VISSR data from GMS satellite and the HRPT data from both FY-1 and NOAA satellites operationally. These data are processed at SMC to generate various satellite cloud images and quantitative products, such as atmospheric temperature and humidity profiles, total ozone content, sea surface temperature, longwave radiation, vegetation index etc.

2.2 In addition to the weather forecast, the satellite data are also used in forest fire, flooding and sea ice monitorings, river mouth silt diffusion detection and wheat yield estimation.

2.3 The Chinese Central TV has set up a five-minute "Meteorological Information Service Programme" which is welcomed by the meteorologists and the public over the country since July of 1990. The Programme broadcasts on the TV once a day with various satellite images, synoptic charts and cloud image animations.

PART III A description of techniques development and applications of satellite data, derived products and services

3.1 The SMC is also actively working on the research of satellite data processing and application. Some projects, such as the development of the TOVS data retrieval model and retrieval method with the impact of the Tibetan Plateau, have made progress.

3.2 In 1990 development of the PC-based meteorological satellite data receiving and processing systems has made considerable progress in China.

3.3 The PC-based data receiving and processing system is able to receive and process the stretched VISSR data from GMS satellite, as well as the HRPT data from FY-1 and NOAA satellites. This PC-based satellite data receiving and processing system has the capabilities of satellite data real time ingest and display, preprocessing image/graphic processing and display, quantitative data processing, conventional data processing, overlap of satellite data and conventional data, file management and data archiving etc.

3.4 The functions of the system's hardware and software are fairly good, the mainframe of the system is either a PC 286 or 386 with a colour monitor, image board and various I/O interfaces. Up to now, most of the provincial meteorological services of China have been equipped with the system.

PART IV System for satellite applications in current operational use

4.1 In 1990, SMC started to construct the ground segment for the geostationary meteorological satellite FY-2. Great progress has been made in the development of the Command and Data Acquisition Station (CDAS).

CZECHOSLOVAKIA

Slovak Hydrometeorological Institute

PART I Summary of the major highlights of research applications and operational changes

1. The following are highlights of recent research: calculations of the reflected component of radiation in channel 3 of the AVHRR; applications to research of strong convective storms; snow cover recognition; and vegetation index calculations.

PART II Major research and development in the applications of satellite data, derived products and services

2.1 The Czech Hydrometeorological Institute developed a method for determination of the radiation temperature component through the calculation of reflectivity in the 3rd AVHRR channel connected with the upper boundary of cloudiness. In case of substantiating of the connection between the increased reflectivity value and hail occurrence, in the future it would be possible (after including of the 3rd channel into geostationary satellite) to utilize it for the timely recognition of storms producing hail. Work has started on utilization of the 3rd AVHRR channel for snow cover recognition.

2.2 On the basis of data from the 1st and 2nd AVHRR channels, the Institute is carrying out a vegetation index calculation on the territory of CSFR with introduction of boundaries into picture and with geometric transformation.

PART III A description of techniques development and applications of satellite data, derived products and services

3.1 Regulary received data include satellites NOAA 10, 11 (2 flights before noon, 2 flights afternoon) - the 1st - the 4th channels + TOVS.

3.2 Data archiving for approximately 1 month, selected situations are being archived definitely.

3.3 Received formats CTOT, DTOT, ETOT, CID, C2D, LY, E1, E2, D1, D2 from Meteosat.

3.4 Distribution of images via telefax transmitter to the department of forecasts of CHMI, to the department of aviation meteorology in Prague-Ruzyne and to HPU.

PART IV System for satellite applications in current operational use

4.1 Accepting station of fy MDA with digital data entry on magnetic type 1600 bpi, telephotoregistrator Muirhead, telephoto-transmitter.

4.2 Data receiver SDUS from Meteosat satellite.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. Data processing from NOAA and Meteosat on PC/AT.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

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EUMETSAT

Federal Republic of Germany

PART I Summary of the major highlights of research applications and operational changes

1.1 Major progress was achieved in the METEOSAT Operational Programme (MOP) since 1987. The last satellite of the preoperational series, METEOSAT-3, was successfully launched on 15 June 1988. The first operational satellite METEOSAT-4 was launched successfully on 6 March 1989 and was the main operational EUMETSAT satellite during 1990.

1.2 A new mission, Meteorological Data Distribution (MDD), was introduced into operations in early 1990. Its objective is to disseminate meteorological products originating from meteorological centres in Europe and Africa within the telecommunications range of METEOSAT.

1.3 EUMETSAT has established facilities to operate two METEOSAT satellites in parallel. These will be used to operate a spare satellite over the Atlantic, when needed.

PART II Major research and development in the applications of satellite data, derived products and services

Meteorological Products

2.1 Much effort was dedicated to the improvement of meteorological products from METEOSAT since 1987. A strong interest has been expressed by EUMETSAT data users in cloud motion winds. According to several authors, such data have a negative speed bias which is correlated with wind speed itself. Improvements of the cloud wind extraction scheme at the Meteorological Information Extraction Centre (MIEC) have resulted in progressive reduction of speed bias. The latest version of the wind processing scheme was put into service on 28 February 1990. It uses information on spatial coherency for better discrimination and height assignment of cloud tracers. Relevant verification results are presented in PART VI.

2.2 A study of wind extraction from METEOSAT water vapour channel data was completed by Laboratoire de Meteorologie Dynamique, France. The resulting scheme was taken over by the MIEC team for adaptation to the operational scheme.

2.3 A EUMETSAT Research Fellow has been placed at ESOC to conduct further research on wind extraction from METEOSAT visible channel data.

2.4 The Sea Surface Temperature product was redefined in November 1989. So far, the product was composed from SST data from cloud free regions during the past 36 hours. The redefined product relies on data from the last 12 hours only. Furthermore, the criterion for cloudiness was handled more rigorously in order to reduce the effect of clouds partially filling up the field of view, which causes a negative bias on SST results.

2.5 A flight campaign was carried out in 1989 for EUMETSAT by the Deutsche Forschungsanstalt für Luft- und Raumfahrt (DLR), Germany, to calibrate the METEOSAT-4 Visible channel by simultaneous measurements of an airborne radiometer. Resulting calibration factors are target dependent. The full report will be published in publication EUM P08. An abstract of resulting calibration factors is given in Table 1.

Table 1

Calibration factors of the DLR calibration flight campaign of 1989 for the METEOSAT-4 visible channels.

Target	Calibration factor $Wm^{-1}sr^{-1}count^{-1}$
Ocean	1.40
Land	1.12
Cloud	0.99

Research

2.6 A Research Fellowship programme was set up by EUMETSAT in 1989. Its objective is to carry out research into improvement of utilization of satellite data and of product extraction algorithms. Two EUMETSAT Research Fellows started work at the European Centre for Medium Range Weather Forecasting (ECMWF) to process passive microwave data and improve the retrieval of vertical sounder data. Another EUMETSAT Research Fellow started work on wind extraction from METEOSAT visible data at ESOC.

Conferences, Workshops

2.7 A conference of AVHRR users was organized by EUMETSAT from 5 to 8 September 1989 in Rothenburg, F. R. Germany. Major topics were multispectral processing and climatological use of AVHRR data.

2.8 A Workshop on the Use of Satellite Data in Nowcasting and Very Short Range Forecasting was jointly organized by EUMETSAT and the British Meteorological Office at the Meteorological Office College at Reading, United Kingdom, 16 - 20 July 1990. One major objective of this workshop was the potential use of the METEOSAT Second Generation (MSG) satellite system for nowcasting applications, and the requirements this might put on the MSG instruments.

2.9 The 8th METEOSAT Scientific Users Conference was held from 28 to 31 August 1990 in Norrköping, Sweden, jointly organised by EUMETSAT and SMHI.

2.10 Proceedings of these conferences are listed in Part VII of this report.

PART III A description of techniques development and applications of satellite data, derived products and services

Atlantic Data Coverage

3.1 Preparations were made for operating a spare METEOSAT satellite over the Atlantic Ocean at 50 degrees West as a backup to provide a new Atlantic Data Coverage (ADC) mission. The ADC programme foresees image preprocessing and dissemination of time multiplexed digital image data by the central ground segment at ESOC, Darmstadt, and WEFAX transmissions by the facilities at CMS, Lannion, France.

3.2 The necessary duplication of the central facilities for reception, transmission and preprocessing of data was completed in 1990. They were already used to exploit data from the spare METEOSAT-3 satellite during those periods when the METEOSAT-4 radiometer was not performing nominally because of decontaminations or tests.

Image Dissemination

3.3 Digital headers were included in all WEFAX transmissions from METEOSAT from 1 August 1990 onwards. The previous WEFAX standard was based on the Automatic Picture Transmission (APT) service designed for continuous recording of image data from polar orbiting spacecraft. WEFAX was an extension of this standard for the use on geostationary satellites and cable networks and did not originally foresee any such sort of annotation.

3.4 The eighteenth meeting of the "Co-ordination of Geostationary Meteorological Satellites (CGMS-XVIII)" adopted a standard for a digital header in analogue WEFAX transmissions to identify automatically the content of the picture transmitted. This header has now been implemented in all WEFAX transmissions from METEOSAT from 1 August 1990 onwards for data originating at ESOC.

3.5 A new Meteosat Dissemination Schedule was introduced on 1 August 1990. Following the introduction of a real-time rectification processing scheme in the METEOSAT Ground Computer System (MGCS) the dissemination of image data was advanced by 12 minutes. This was a considerable improvement and will improve nowcasting use of data.

3.6 The relay of GOES image data via METEOSAT via the GOES 2 satellite and the Centre de Meteorologie Spatiale (CMS) in Lannion, France, was continued. The success rate of this relay service was limited by the fact that the inclination of GOES is high and not correctable any more.

3.7 There has been no progress in attempts to access INSAT data for relay via METEOSAT.

3.8 The number of registered users of the METEOSAT dissemination mission has been 109 for the High Resolution and 1099 for the WEFAX dissemination schemes respectively by the end of 1990.

Meteorological Data Distribution (MDD)

3.9 Regular MDD transmissions have been performed on a pre-operational basis since the beginning of 1990. The complete system was officially handed over from ESA to EUMETSAT on 1 April 1990.

3.10 The current system consists of the two EUMETSAT uplink stations in Bracknell and Rome and several prototype user stations. EUMETSAT regularly monitors the transmissions at its headquarters in Darmstadt.

3.11 The EUMETSAT station in Rome transmits a selection of alphanumeric (e.g. SYNOP, TEMP, and PILOT) messages, whilst the EUMETSAT station in Bracknell transmits digital weather charts. Aviation forecast charts are relayed from Bracknell, Paris, Offenbach and Las Palmas, via Madrid. Special forecast charts covering the African equatorial regions are also provided by ECMWF. The AGRHYMET centre in Niamey regularly transmits a series of agrometeorological charts produced by that centre.

3.12 An evaluation of MDD demonstrations is carried out by World Meteorological Organisation in Geneva, using user stations located in the National Meteorological Centres of Niamey and Nairobi.

3.13 A facility for encryption of MDD data is being developed to ensure effective control of the data. It is designed such that distribution and updating of encryption keys will be fully automatic. Operational dissemination of encrypted data is planned to start by the end of 1991. Authorized users of the system will receive encryption decoding key units from EUMETSAT. Access to data is free of charge to National Meteorological Services.

3.14 At present the MDD mission uses two data streams relayed via METEOSAT-4 at reception frequencies:

1695.7250 MHz (MDD channel 2)
1695.7874 Mhz (MDD channel 4)

3.15 Potential users of MDD should contact EUMETSAT for admission to the MDD system, the transmission schedule, technical documentation and reference to equipment manufacturers.

Data Collection System (DCS)

3.16 Interference on DCS channels has increased and affected more and more channels over recent years. A joint initiative has been taken with the WMO Secretariat and other satellite operators to ensure the protection of the radio frequency band in the range between 402-403 Mhz by international agreements.

3.17 The total number of registered Data Collection Platforms (DCP) using METEOSAT increased from 416 to 673 during the year. The number of DCP messages transmitted on the GTS increased from about 30000 to about 40000 per month.

3.18 A co-operation agreement was signed between EUMETSAT and CLS ARGOS, France. It covers the provision of services to users operating DCP which do not contribute to WWW programmes, and is limited to the use of the Regional channels. This service may be of interest to those users who are operating a DCP over a limited period of time and want to limit their investments into processing facilities. It also offers "value added" data processing and access to the data via telephone and other public networks.

3.19 For further information on these services, potential users should contact:

In Europe:	CLS Service MAEDS 18 Ave Edouard Belin 31055 Toulouse CEDEX France	In USA:	North American CLS 1801, McCormick Drive, Suite 10 Landover, MD USA
Tel No. (intl 33) 61 39 47 00		(intl 1) (301) 341 18 14	

EUMETSAT - Electronic Bulletin Board

3.20 A EUMETSAT Electronic Bulletin Board (EBB) has been set up by EUMETSAT in order to provide up-to-date information about Meteosat, other meteorological satellite systems, conferences and related activities. This EBB will operate in complement with the EBB successfully developed by NOAA/NESDIS over recent years. The information service is accessible 24 hours every day from any country in the world.

3.21 On the user side an asynchronous terminal or a micro-/personal-computer is required. The asynchronous port should be connected via a modem or an acoustic-coupler to the national packet switching or telephone network.

Access using the Packet Switching Network DATEX-P

3.22 The EUMETSAT EBB can be accessed directly via national packet switching networks. Data transfer via these networks is less expensive than using the direct telephone lines.

The EUMETSAT EBB NUI is

45 6151 30059 (from Federal Republic of Germany)

262 45 6151 30059 (from all other countries)

3.23 The modem or acoustic-coupler should operate with data transfer rates of 300, 1200 or 2400 bit/sec (ORIGINATE, FULL DUPLEX) and the user's telecommunication software should use 8 Data Bits, No Parity and 1 Stop Bit.

Access using direct telephone lines

3.24 The two direct telephone lines can be accessed using one single telephone number:

06151 51052 (from Federal Republic of Germany)

++49 6151 51052 (from all other countries)

3.25 The following standards are applicable: 1200 bit/sec, V.22, or 2400 bit/sec, V.22bis, 8 Data Bits, no Parity and one Stop Bit.

3.26 Further details will be given in the EBB Manual which can be obtained from EUMETSAT.

PART IV System for satellite applications to meteorology and operational hydrology

4.1 The METEOSAT system is operated on behalf of EUMETSAT by the European Space Agency (ESA) and covers both, satellite and ground segment operations. Satellite operations since the launch of the first satellite are:

Satellite	Launch	Operations
METEOSAT-1	23 November 1977	Nov 77 - Nov 79
METEOSAT-2	19 June 1981	Jun 81 - Aug 88
METEOSAT-3	15 June 1988	Aug 88 - Jun 89 Jan 90 - Apr 90
METEOSAT-4	06 March 1989	Jun 89 - Jan 90 Apr 90 - Dec 90

4.2 METEOSAT-2 is positioned at 10 degrees West in hibernation mode and has an uncorrectable inclination in excess of 3.5 degrees. However, it is still able to scan images of good quality.

4.3 METEOSAT-3 was positioned at 4 degrees West to serve as backup to the operational METEOSAT-4. Only dissemination channel A1 at 1691.0 Mhz is operating on this satellite.

4.4 All operational missions have been supported by METEOSAT-4 since 19 April 1990.

4.5 A fuller description of the METEOSAT system is given in WMO Publication No. 411.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

METEOSAT System

5.1 METEOSAT-5 was launched on 2nd March 1991, METEOSAT-6 is planned for launch in September 1993.

5.2 At least one additional satellite of the same series is foreseen to be built and launched in the framework of the METEOSAT Transitional Programme (MTP) to continue operations of the METEOSAT system after the end of the current programme (end 1995).

5.3 METEOSAT Second Generation (MSG) will be the follow-on of the current generation of METEOSAT/MTP satellites. The launch of the first MSG satellite is planned for 1998. The baseline will be a spinning satellite with a 12-14 channel multispectral imager as main payload to support basic multispectral and high resolution visible imaging as well as air mass analysis missions. The channels of the multispectral imager are still in the definition stage. A baseline set of channels agreed will include, at least, those of the current AVHRR instrument, two channels in the 6-7 @m water vapour band region, a channel in the 13-14 @m band for more accurate cloud height assignment, and possibly a total ozone channel at 9.6 @m. The horizontal resolution of these channels is planned to be about 3 km at the Sub Satellite Point (SSP). In addition, there is a high resolution (1 km SSP) broadband visible channel foreseen to support nowcasting over the European area.

5.4 The data collection mission will be continued and improved. MDD and WEFAX will be combined into a new "Low Rate Information Transmission (LRIT)" at a higher data rate than the current system.

5.5 Transitional periods of several years between the old and the new dissemination schemes are foreseen.

Polar Orbiting Satellites

5.6 The EUMETSAT Polar System (EPS) programme is planned as a European contribution to the system of the polar orbiting satellites of the space based subsystem of the GOS. The objective is to ensure long term continuity of data from polar orbiting environmental satellites by operating a satellite in the morning orbit as a complement to the afternoon orbiter operated by the USA, and to provide meteorological payload in exchange for instruments obtained from the USA. This should ensure maximum compatibility of data from both, the morning and the afternoon satellite.

5.7 Major elements of the planned EPS programme are the provision of

- a microwave sounder instrument to the next generation of polar orbiting satellites and platforms;

- a direct broadcast facility for meteorological data from the polar platforms of ESA;

- polar orbiting environmental satellite operations in morning orbit as a long term programme, some of the instruments to be provided by the USA.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6.1 Verification data of cloud motion winds since 1983 have been evaluated by EUMETSAT. Important improvements to the wind extraction scheme are summarized in Table 2. Figure 1 shows the monthly averages of speed bias

Table 2

History of changes of METEOSAT product extraction methods affecting the accuracy of cloud motion winds

Period	months	Changes of methods
Mar 83 - Nov 84	23	IR calibration: SST within ± 0.5 K RMS
Nov 84 - Feb 87	28	Revision of automatic and manual QC
Mar 87 - Aug 87	6	Radiance windowing, high level winds
Sep 87 - Mar 89	19	WV calibration
Apr 89 - Feb 90	11	Guided peak search using ECMWF FG winds
Mar 90 - Feb 91	12	Using spatial coherency information

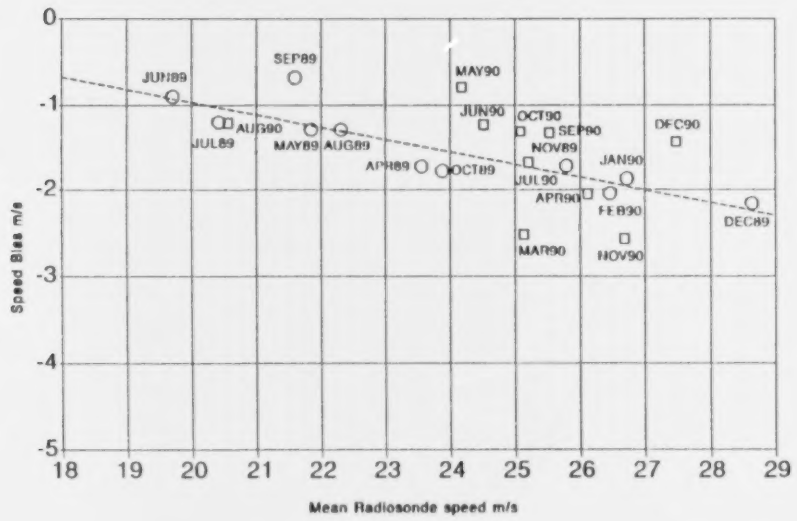


Figure 1: Scatter diagram between monthly average speed bias and verifying radiosonde speed. Squares: monthly averages since March 1990. Dashed: Regression line between averages during the period from April 1989 - February 1990

of high level winds since April 1989, plotted as scatter diagram against verifying radiosonde speed, thus covering the effects of the last change of February 1990. Taking account of the apparent regression between bias and speed, there is an "upward" trend from the beginning to the end of the period. Most monthly averages after the change of February 1990 are plotted above the bias/speed regression line for the period from April 1989 to February 1990. The vertical distance of the points from the regression line suggests a quantitative estimate of the net speed bias improvement.

6.2 A similar verification technique was applied to all METEOSAT cloud motion winds since 1983. Figure 2 shows overall averages of bias and speed over the different periods defined in Table 2, and regression lines attributable to each period. It is evident that there have been several distinct steps of improvement since 1987. It should be mentioned that corresponding improvement has also been observed for the RMS vector differences as well as the speed bias. The relevant diagrams are not shown for conciseness.

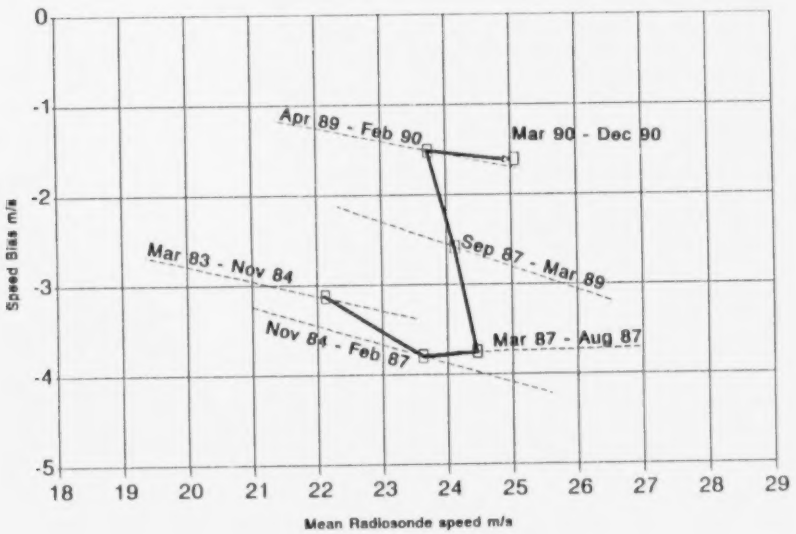


Figure 2: History of METEOSAT high level cloud motion wind improvements since 1983. Squares: speed bias versus radiosonde speed averaged over the whole period indicated. Lines: Regression lines between bias and speed during the period indicated.

6.3 Table 3 shows monthly averages of SST bias and RMS error from verification with conventional measurements from ships.

Table 3

MIEC Sea Surface Temperature Bias and RMS differences from conventional SST measurements.

	BIAS 00 UTC	BIAS 12 UTC	RMS 00 UTC	RMS 12 UTC
JAN90	-0.09	-0.15	1.09	1.16
FEB90	-0.20	-0.23	1.05	1.08
MAR90	-0.46	-0.38	1.26	1.17
APR90	-0.44	-0.46	1.10	1.11
MAY90	-0.30	-0.29	1.18	1.15
JUN90	-0.40	-0.35	1.23	1.21
JUL90	-0.33	-0.30	1.19	1.15
AUG90	-0.29	-0.31	1.09	1.07
SEP90	-0.21	-0.29	1.08	1.13
OCT90	-0.19	-0.29	1.09	1.16
NOV90	-0.12	-0.28	1.26	1.21
DEC90	0.06	-0.18	1.14	1.13

6.4 A wind intercomparison campaign has been arranged between NOAA/NESDIS, ESA, ECMWF and the national meteorological service of Spain. It encompasses METEOSAT and GOES data from their overlap area over the Atlantic during the period from the 6 - 31 August 1990. Validation by participants is expected to be completed in 1991.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

7.1 References

Most of the papers of EUMETSAT authors were published in the series of EUMETSAT publications EUM P 01 ... EUM P 08. In addition, the following scientific papers contain relevant information:

Henri Laurent: Feasibility Study on Water Vapour Wind Extraction Techniques. Laboratoire de Meteorologie Dynamique du CNRS, France, September 1990

M. Perrone: Use of VAS data for simulation of future METEOSAT Products. ECMWF/EUMETSAT Workshop on The Use of Satellite Data in Operational Weather Prediction: 1989-93, 9th-12th May 1989.

J. Schmetz, M. Nuret: Cloud Motion Wind Estimates in Europe. ECMWF/EUMETSAT Workshop on The Use of Satellite Data in Operational Weather Prediction: 1989-93, 9th-12th May 1989.

J. Schmetz: Cloud Motion Winds from METEOSAT: Performance of an Operational System. To appear in "Global and Planetary Change", 1990.

J. Schmetz: Operational Calibration of the METEOSAT Water Vapour channel by calculated radiances. Applied Optics 28, 1989.

J. Schmetz, K. Holmlund: Operational Cloud Motion Winds from METEOSAT. To appear in: Advances of Space Research.

H. Woick: Verification of Cloud Motion Winds at Global Scale. To appear in: Advances of Space Research.

7.2 EUMETSAT Brochures and Conference Proceedings

EUM P 01 The 6th METEOSAT Scientific Users Meeting, Amsterdam, 25th-20th November 1986

EUM P 02 Satellite Meteorology and its Extension to Agriculture, Erice, Sicily, Italy, 13th-20th November 1986

EUM P 03 Workshop on Satellite and Radar Interpretation, Reading, UK, 20th-30th September 1987

EUM P 04 The 7th METEOSAT Scientific Users' Meeting, Madrid, Spain, 27th-30th September 1988

EUM P 06 Proceedings of the 4th AVHRR Data Users Meeting, Rothenburg, Fed. Rep. of Germany, 5-8 September 1989

EUM P07 Proceedings of the Workshop on the Use of Satellite Data in Nowcasting and Very Short Range Forecasting, held in Shinfield Park, UK,

EUM P08 Proceedings of the 8th METEOSAT Scientific Users Meeting, held in Norrköping, Sweden.

7.3. EUMETSAT Documentation - METEOSAT System Guide

Documentation describing the METEOSAT System has been updated and can be obtained from EUMETSAT. A list of these documents, with issue dates, is given below:

1. Introduction to the METEOSAT Operational System, ESA BR-32, Sept. 1987

2. METEOSAT WEFAX Transmissions, March 1990

3. METEOSAT High Resolution Image Dissemination, October 1989

4. METEOSAT Primary Data User Station, August 1980

5. METEOSAT Data Collection System, March 1990

6. METEOSAT DCP Satellite Retransmission System, January 1990

7. MIEC Processing, ESA STR-224, Sept. 1987

8. METEOSAT Data Service, Issue 3, March 1990

9. METEOSAT Magnetic Tapes and Files Description, Issue 4, July 1987

7.4 For EUMETSAT documentation, an amount of DM 10.-- per brochure will be charged to the users of countries participating in the METEOSAT programme* and DM 15.-- for other users.

7.5 If ordering, a cheque of the required amount, made payable to EUMETSAT, Darmstadt, must be attached to any order.

7.6 Requests for documentation may be addressed to:

The Director
EUMETSAT
Am Elfengrund 45
6100 Darmstadt-Eberstadt
Federal Republic of Germany

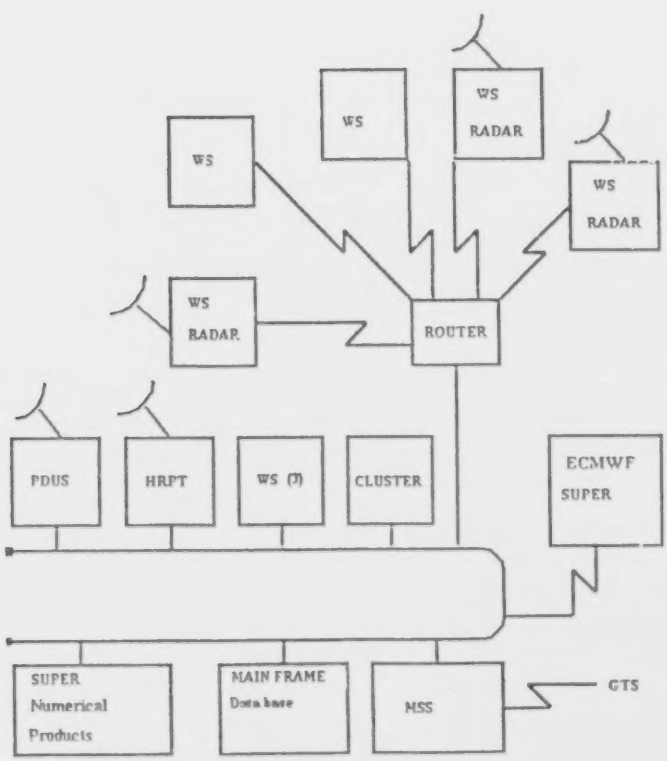
* Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom.

FINLAND

Finnish Meteorological Institute

PART I Summary of the major highlights of research applications and operational changes

1.1 Both image data from geostationary and image/sounding data from polar orbiting satellites are received and processed for operational and research purposes. A PDUS receiving system for Meteosat data has been working operationally since 1986 and the images are processed in real time. A separate receiving and processing system for NOAA HRPT data has been available since 1987. Meteosat images are also transferred to the Meteorological workstation, where they can be displayed together with conventional observations. These workstations are also used in regional forecasting offices. NOAA AVHRR images can only be viewed within the processing system in the central office. Sounding data (TIP) are routinely processed and temperature/ humidity profiles calculated. The following figure shows the computer system and the overall configuration (WS=workstation).



PART II Major research and development in the applications of satellite data, derived products and services

Satellite Soundings

2.1 The satellite sounding processing system is designed so that when the full satellite pass is ready the TIP data are transferred directly to CRAY-XMP (Centre for Scientific Computing), where the preprocessing steps as well as the inversion to a full temperature and humidity retrievals are carried out. Soundings are solved for each line and for each spot using the ITPP software from Wisconsin. The aim is to use the soundings (or raw radiances) in the data-assimilation step of the limited area forecasting system (HIRLAM). Since it seems to be difficult to prove the usefulness of satellite sounding data in improving the quality of forecasts at least in data dense areas, priority is given for the evaluation of brightness temperature "images" in synoptic use. Later the retrieval system will be integrated into the data-assimilation system.

SAAMEX, Microwave measurement campaign - Finland 1990

2.2 Future NOAA satellites will include the Advanced Microwave Sounding Unit (AMSU), with 20 channels located in the microwave region 20-190 Ghz. An airborne measurement campaign was carried out in Finland during the second half of March 1990. A two channel (89 GHz and 157 GHz) microwave radiometer, M RSS (Microwave Airborne Radiometer and Scanning System) designed by the British Meteorological Office and Laboratoire de Meteorologie Dynamique, fitted to the UK Meteorological Office Research Aircraft C-130, was used in the campaign together with radiometers and radars ranging from 5 to 90 Ghz and constructed by the Laboratory of Space Technology Helsinki University of Technology. Extensive ground measurements were carried out over four lines. The principal targets were sea ice, snow covered terrain and open sea. Benefits from the campaign are expected in the understanding of boundary parameters, different characteristics of surface and cloud properties and in instrument validation. In the end this should lead to improved future atmospheric sounding capability.

2.3 The following institutes participated in the campaign:

United Kingdom:

- British Meteorological Institute (BMI)
- Oxford University

France:

- Laboratoire Meteorologie Dynamique (LMD)
- Department de Radioastronomie Millimetrique
- Observatoire de Meudon

Finland:

- Finnish Meteorological Institute (FMI)
- Helsinki University of Technology (HUT)
- National Board of Waters and Environment
- Finnish Institute of Marine Research
- Finnish Institute of Forest Research

The use satellite images in estimation of rainfall in northern latitudes

2.4 There are several reasons, why forecasters need a more dense rain observation network, than normal synoptical observations can offer. Numerical models are still slow to forecast appropriate amounts of precipitation during the first few hours of integration (spin-up problem). Furthermore the meteorologist does not have rain observations over oceans. This leads to difficulties in forecasting rain and rainfall intensities. The weather radar network might be one solution, but again oceans are not covered and there are gaps between radar observations on land. Combined satellite estimated rain and weather radar rainfall can offer proper spatial and timely coverage. In Finland use of geostationary satellite data (Meteosat) in estimating rainfall is not possible during the winter and at night due to our northern location. Also the spatial resolution is rather poor. Therefore we are using polar orbiting meteorological satellites (TIROS/NOAA) as the primary satellite data source.

2.5 Over the last years many institutes and universities have made studies in estimating rainfall from satellite data. In our case we have selected from those results two slightly different methods, one, which is mainly effective over oceans and used in numerical forecast models, the other statistical box method classification. Both of these methods need statistics over long periods and adjustment to fit to desired geographical conditions. The purpose is to develop a rainfall observation, which covers Finland and parts of Scandinavia, to be used in numerical models and as a composite image with radar observations at the meteorological workstation in everyday forecasting.

2.6 There are many problems and points to consider in both methods used: sun elevation, satellite-sun azimuth angle, layered clouds, reflectivity of underlying surface, shadows etc. Some of these problems can be solved by statistical or physical methods, but some are so complex, that they have to be neglected in a real-time application. As a conclusion and a compromise to these it is decided to make the first rain rate estimation product only once a day at noon, when the sun is highest, and from late spring to early autumn so that it is unlikely to get snow or hail and to avoid ice and snow surfaces. As important as the product itself is also the reliability of the product. Because we already know, there are cases impossible to our algorithms, we try to make a factor, which tells the uncertainty of the real-time product. The other way to guarantee the best possible result is to display the rain classification composite on the original cloud image to give the meteorologist grounds to estimate the accuracy of the product himself.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

Aulamo H., Pylkko P., "Using satellite images to estimate rainfall latitudes". Proc AVHRR USER MEETING 1991.

Uppala S., Foot J., Chedin A., Scott N A., Sirou F., Hallikainen M.

"SAAMEX - Surface and Atmospheric Airborne Microwave Experiment, Finland 1990", Proc IGARSS 1991.

English 5., Foot J., Jones D., Stringer S., Greener B., Encrenaz P , Chedin A., Scott N., Claud C., Sirou F., Uppala S., Hallikainen M.

"Radiometric observations at 89 and 157 GHz of atmospheric and surface properties measured from an aircraft". Proc IGARSS 91.

Hallikainen M., Panula-Ontto E., Jaaskelainen V., Toikka M., Pulliainen J., Tares T., Ahola L., Kurvonen L. and Tauriainen S. "Microwave radiometer and radar measurements in the SAAMEX campaign". Proc IGARSS 91.

Lepparanta M., Simila M., Kalliosaari S., Kosloff P., Palosuo E. and Repo J., 1990 . "SAAMEX-Sea Ice Data Report". Finnish Institute of Marine Research, Internal Report 1990 (9).

Image processing: Pirkko Pylkko
Hannele Aulamo
Sigbritt Nasman

Satellite soundings: Sakari Uppala
Aarno Korpela

Address:

Finnish Meteorological Institute
Weather Department
Box 503
SF-00101 Helsinki
Finland

Telefax: +358 0 179581
Telephone: +358 0 19291

FINLAND

Finnish National Board of Waters and the Environment

Operational hydrology

PART III Main Projects

3.1 The interpretation of the land use and forest classes (by Landsat TM). The investigation of Finland is now done and we have got about 50 different classes. This information in digital form is connected to the watershed information and the output is classes of the land use and forest classes in the framework of big water areas as well as in the framework of smaller areas.

3.2. More detailed interpretation of the use of soil and stand from natural protection areas (by Landsat TM).

3.3 The quality of waters. This project is only at the beginning. (by Landsat TM, Landsat MSS, NOAA AVHRR).

3.4 Surface temperature and the vegetation index (by NOAA AVHRR). The pictures in almost real time are sent from the Finnish Meteorological Institute from 1. of April to 31. October. The data is being used for example in hydrological models.

PART IV Equipment and programmes

Two workstations, Apollo 5500 and HP/Apollo 9000/433s and DISIMP software for image processing. It is also possible to mix and analyze satellite data with vector data with the help of FINGIS or Arc/Info GIS-programmes.

PART VII Publications

Y. Sucksdorff and C. Ottle, 1990: Application of Satellite Remote Sensing to Estimate Areal Evaportranspiration over a Watershed in Journal of Hydrology, 121(1-4): 321 333.

Y. Sucksdorff, G Michels, S. Tattari and M. Heikinheimo, 1991: Operational Satellite Remote Sensing for Hydrological Modelling to be published in IGARSS'91 proceedings, Espoo, Finland.

FRANCE

Météorologie Nationale

PART I Summary of the major highlights of research applications and operational changes

1.1 Operational use of TOVS data in data assimilation as SATEMs in the global model EMERAUDE and as raw radiances in the limited area model PERIDOT.

1.2 Ongoing important effort of research and development in the building up of the future numerical weather forecasting suite ARPEGE-IFS developed in close co-operation with ECMWF.

PART II Major research and development in the applications of satellite data, derived products and services

Mesoscale analysis

2.1 The PERIDOT data assimilation whose main characteristics are: continuous, with a 12-hour cycle (the guess is a 12 hour forecast of PERIDOT itself); direct use of TOVS raw radiances; final analysis state obtained by a blend of PERIDOT and EMERAUDE analysis according to horizontal scale (small scale features kept from the PERIDOT analysis, large scale features taken from the EMERAUDE analysis) has been operational since 1986.

2.2 The main lessons learned from five years of operational experience in relation to the use of satellite data are:

- there is a potential of analysis at the mesoscale in a PERIDOT like data assimilation system (JUVANON DU VACHAT et al), which can benefit from the use of SATEMs at their lowest resolution (120 km) (DURAND and PEIRRARD);
- the use of humidity information is far from optimal;
- future data assimilation systems should be geared to make use of satellite information in the most direct way (use of cloud clear and better raw radiances).

2.3 Recognizing that data assimilation is handicapped at the mesoscale by the necessary specifications of lateral boundary conditions in limited area models, the future ARPEGE-IFS system has been designed to provide the possibility of doing both data assimilation and forecast at a resolution equivalent to the PERIDOT system over a region similar to the current PERIDOT domain within a global model. This is obtained by using a Frank-Schmidt transformation on the sphere.

2.4 Improvement of the use of satellite data will come from a variational data assimilation technique, which has required the development and the coding of fast radiative transfer models and their adjoints within the same system.

(M-C. Pierrard, C. Blondin, P. Courtier, P. Moll - Paris)

PART IV System for satellite applications in current operational use

Operational analysis

4. In June 1988, the EMERAUDE large scale model (spectral T79) became global (it was hemispheric before). In terms of assimilation of satellite data, the major change concerned the use of SATEMs at the 250 km resolution from December 1989 onward. Preparations are underway to switch to the SATEMs 120 km in the Spring of 1991. Only the wind part of the SATOBs data continue to be used.

(M-C. Pierrard)

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

The use of satellite data in the operational SST analysis

5.1 A sea surface temperature analysis is carried out using an O.I. analysis scheme for the global EMERAUDE and the regional PERIDOT models, at two different horizontal resolutions. The major purpose is to develop an SST analysis for the global ARPEGE model, using an O.I. scheme on a stretched and rotated Gaussian grid. The operational models use in situ data only, so studies are underway to introduce satellite data in the analysis. The derived SST used are computed by the Centre de Météorologie Spatiale in Lannion (SCEM/CMS) for its acquisition domain; the surface temperature is calculated from IR measurements and the final SST is derived using the AVHRR cloud mask (NOAA satellite data).

5.2 The two kinds of data (in situ and satellite) have been compared over a one year period (1989) and found to be consistent with similar structure functions over each studied area. For the time being we are computing reliable statistics for the satellite data to be introduced into the operational regional analysis.

(F. Taillefer)

Towards an operational use of scatterometric data in NWP models

5.3 Over the past five years Météo-France has contributed to a research programme entitled AMERS, a co-operative effort with SHOM, IFREMER and CNES, to develop an original approach to use the scatterometric data of ERS-1. The goal is to use this kind of data directly in a variational analysis (under development at Météo-France). The programme contains four major aspects: validation, calibration, inversion and assimilation of the inversed winds. An operational set of programmes is ready to use the ERS-1 data as soon as they are available.

5.4 The main point of our approach is to obtain directly a wind field for the whole swatch and not a set of independent winds. This approach allows a better filtering of the noise, and the possibility of using all the information even if some data are missing, e.g. in areas where only two of the three beams are available.

5.5 To inverse scatterometric data from ERS-1, a variational method involving four minimization stages has been developed. The ambiguity is not removed directly but through constraint terms on the direction of the nearest winds at the two latest stages of the minimization of the cost function.

5.6 The calibration of the backscatter model is made by minimizing a cost function using NWP products and scatterometer data. The use of the Hessian matrix speeds up the convergence.

5.7 This year, we are going to validate ERS-1 data, both normalized radar backscatter sections and derived winds. We plan to produce maps combining operational analysis and ERS-1 data as an input to the oeanographic community.

5.8 We shall make statistics to study the behaviour of the scatterometer data with respect to the incidence angle, stability of the boundary layer, SST. Attention will be paid to the internal consistency of the inversed wind.

5.9 Work is also carried out on altimetric data. Cross calibration of the scatterometer and the altimeter will be made in order to detect any drift of the sensors.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

7. Juvanon du Vachat, R., Imbard M., Durand, Y. 1988: TOVS data impact studies of the PERIDOT NWP system on 7 June 1987 case. Proceedings of the IV International TOVS conference, Igls, March 1988; pp 85-98.

Durand, Y. and Pierrard, M-C, 1989: Use and impact of satellite data in the PERIDOT system. Proceedings of ECMWF/EUMETSAT Workshop on "The use of satellite data in operational numerical weather prediction 1989-1993", ECMWF, Reading, U.K., 9-12 May 1989; Vol. 1, pp. 107-137.

Derrien M. and Le Gléau, H. 1988: "Détection opérationnelle de la couverture nuageuse à partir des satellites de la série NOAA", Note EERM.

Roquet H., Ratier A., 1988: Towards direct variational assimilation of scatterometer backscatter measurements into numerical weather prediction models. Proceedings of IGARSS'88, ESA/SP-284, 257-260.

Cassé A., Ratier A., Roquet H., 1990: Direct variational assimilation of scatterometer backscatter measurements into numerical weather prediction models. Proc. of International Symposium on Assimilation of Observations in Meteorology and Oceanography, Clermont-Ferrand, France, 9-13 July 1990.

GERMANY

Deutscher Wetterdienst

PART I Summary of the major highlights of research applications and operational changes

1.1 A new PDUS and a new HRPT system have been taken in operation in 1990. Display and interactive processing of satellite images is performed on an Interactive Graphical System, which is a network of several workstations.

1.2 Research activities were mainly concentrated in the areas of TOVS data processing and in the development of a method for estimating precipitation from METEOSAT data.

PART II Major research and development in the applications of satellite data, derived products and services

TOVS Data Processing

2.1 The "International TOVS Processing Package (ITPP-3)", developed by the Co-operative Institute for Meteorological and Satellite studies (CIMSS), University of Wisconsin in Madison, has been implemented on the new computer system at the Deutscher Wetterdienst and can be run operationally. The quality of derived vertical temperature profiles has reached international standard to a large extent.

2.2 Co-operation activities were performed with the University of Hamburg and the University of Karlsruhe in order to improve further the accuracy of the vertical temperature and moisture profiles from the TOVS data. The University of Hamburg (Grañl/Schlüssel) provided us with an algorithm for a more precise determination of sea-surface temperatures and for detection of inversions near the ground from the HIRS channels. The co-operation with the University of Karlsruhe (Fischer/Olesen/Sun) has the aim to improve the accuracy of vertical temperature profiles by including AVHRR data in the retrieval method in partly cloudy areas.

2.3 After extended sensitivity and impact studies, the retrieved TOVS data will be used in mesoscale numerical weather prediction models and in nowcasting applications.

Humidity Parameters from Microwave Data

2.4 A co-operation activity is ongoing with the University of Kiel (Ruprecht) for deriving atmospheric humidity parameters (vertical profiles for 20 layers, total water vapor content, total liquid water content) from microwave data over sea. Tests are being performed with SSM/I data. Purpose of this co-operation is the preparation on the availability of the AMSU-B instruments.

Precipitation Estimates from METEOSAT data

2.5 After unification of the Meteorological Service of the German Democratic Republic and the Deutscher Wetterdienst, tests have been continued at Potsdam for a method to estimate precipitation from METEOSAT data. This

method relys on availability of IR and VIS data and is based on a classification procedure. Results are areas of intensity probability of precipitation with typical conveyor belt features. The method is sensible with the sun correction methods applied to the VIS images. A detailed verification of the precipitation estimates will be performed.

PART III A description of techniques development and applications of satellite data, derived products and services

Bogus Humidity Data

3.1 The evaluation of vertical humidity profiles by interactive interpretation of METEOSAT images (bogus date) was continued operationally.

Global Radiation at Ground Level from METEOSAT data

3.2 The determination of the global solar irradiance at the ground from METEOSAT data by the method of MüSER and RASCHKE was continued as in the previous years. Results are climatological data sets.

Interactive Satellite Image Processing

3.3 All satellite images available in the Interactive Graphical System (METEOSAT, NOAA-AVHRR) are transformed to polar-stereographic projection; IR images are temperature calibrated and VIS images are contrast normalized taking account on the suns zenith angle. Progress in weather monitoring, nowcasting and monitoring of the quality of numerical analysis and forecasts could be achieved in 1990 by the possibility to superimpose conventional data and output from different NWP models to the satellite images on the workstations.

PART IV System for satellite applications in current operational use

Central Image Processing System at Offenbach

4.1 This system consists of a new PDUS for reception of digital METEOSAT data and a new HRPT system for reception of the NOAA AVHRR and TOVS data. Preprocessing is performed on two MicroVAXes (one for METEOSAT, one for NOAA data) with a VMS operating system. Display and interactive processing of satellite image data is performed in the Interactive Graphical System, which is a network of several workstations CYBER 910-400 (each 16 MB RAM, 12.5 resp. 20 MHz, 1280 * 1024 pixels resolution, 56 bitplanes, animation rate 10 images per second, 1 GByte disk capacity). The operating system is UNIX.

4.2 TOVS date retrieval processing is performed on the two mainframe computers (Cyber 180 - 860 A or Cyber 180 - 990 E). The operating system is NOS/VE.

4.3 Processed images from the central image processing system are transmitted via HF facsimile to regional offices; in addition press agencies and TV agencies are being provided with specially processed images.

Image Processing at Potsdam

4.4 DIGISAT is an operational system for reception, processing and display of digital satellite data: METEOSAT-PDUS as well as NOAA-HRPT. This system consists of a computer I 102 F (Romania) with a MIX operating system, 2 Robotron image processing systems A 6472 and 2 video-graphic recorders for hardcopy generation.

4.5 All images presented in the display system are transformed to polar-stereographic projection and are temperature calibrated resp. contrast normalized. All usual applications can be applied to the digital satellite data: roaming, zooming, animation, pseudo-colour images, etc.. In addition, time-difference images can be calculated and displayed.

Local and Regional Image Reception and Processing

4.6 At the end of 1990, 24 regional offices and meteorological offices at airports of Deutscher Wetterdienst were equipped with their own SDUS. They are used for individual METEOSAT image reception and utilization.

Data Collecting Platforms

4.7 At the end of 1990, 17 Data Collecting Platforms (DCPs) are operated under the responsibility of German authorities or institutes. 8 are stationary platforms, 9 are ship DCPs.

4.8 In addition, 11 German ASAP/DCP units (ASAP = Automated Shipboard Aerological Programme) were registered.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 Regional meteorological centers will be equipped with their own workstations. They will be used for weather monitoring and nowcasting applications by simultaneous display and interactive processing of output from mesoscale numerical weather prediction models, radar data, satellite data and conventional observation data. The satellite data will be received and preprocessed at the central facilities in Offenbach and they will be transmitted to the regional meteorological offices on a digital public network. First test transmissions of digital satellite data from Offenbach to the marine meteorolical office at Hamburg are planned in 1991 on a 64 Kbit/sec data link to prove the practicability of this concept.

5.2 TOVS data will be retrieved regularly from 1991 onwards on a fully operational basis. Quantitative parameters will be derived from AVHRR as input data to NWP.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6. No systematic work has been done in this area.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

7. Benesch, W.; Knottenberg, H.: New satellite data receiving and processing facility at Deutscher Wetterdienst, Offenbach. Proceedings of the 8th METEOSAT SCIENTIFIC USERS' MEETING; 28th - 31st August 1990, Norrköping, Sweden. Compiled by EUMETSAT.

HONG KONG

Royal Observatory

PART I Summary of the major highlights of research applications and operational changes

1.1 The ground reception system was replaced in November 1988 to cope with changes in transmission format from analogue (HR-FAX) to digital stretched-VISSR (Visible and Infra-red Spin Scan Radiometer) mode.

1.2 Cloud imageries in digital format from the Japanese Geostationary Meteorological Satellite (GMS) are received operationally. WEFAX (LR-FAX) from GMS and Automatic Picture Transmission (APT) from the NOAA Satellites are received occasionally as back-up.

1.3 The availability of hourly satellite imageries greatly facilitate the monitoring of tropical cyclones in the northwestern Pacific and the South China Sea.

1.4 SATEM and SATOB were received through GTS and used in operational upper-air analyses.

1.5 SAREP on tropical cyclones issued by the Japanese Meteorological Agency (JMA) were received through GTS and used in operational tropical cyclone analysis and forecasting.

PART II Major research and development in the applications of satellite data, derived products and services

2. A joint project is being carried out by the Royal Observatory and an academic institution to develop a system for identifying cloud texture and cloud type from visible and infra-red satellite imageries.

PART III A description of techniques development and applications of satellite data, derived products and services

Off-line processing of GMS S-VISSR imageries

3. A computer work-station for off-line satellite data processing and display is being developed in-collaboration with a university in Hong Kong. The system is designed to store up to 16 satellite imageries and display the animated sequence on a video terminal. Infra-red imageries are enhanced to highlight sea surface temperature features, sea fog and the development of tropical cyclones.

PART IV System for satellite applications in current operational use

GMS ground reception system

4.1 A block diagram of the GMS ground reception system is shown in Figure 1.

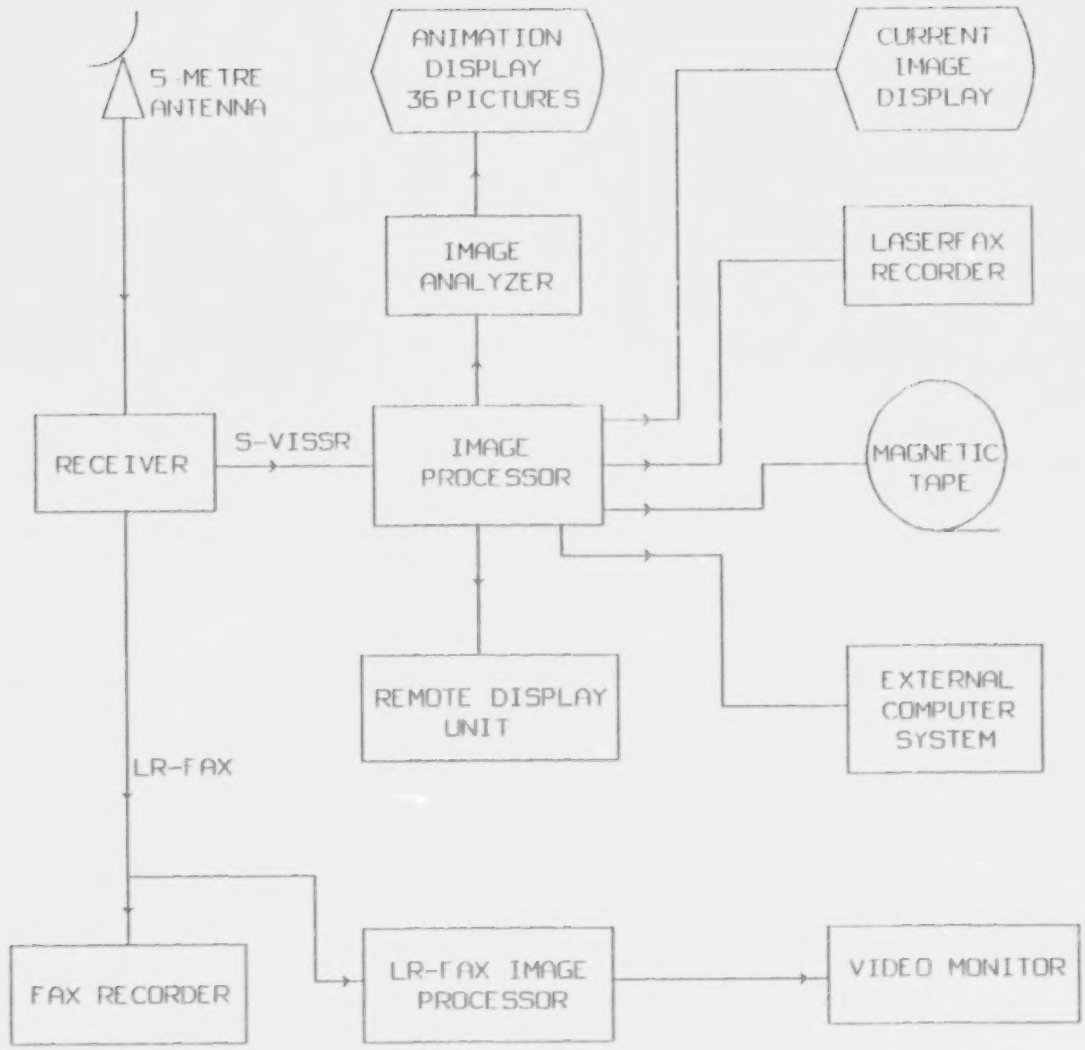


FIG. 1 BLOCK DIAGRAM OF THE GMS RECEPTION SYSTEM

4.2 The equipment consists of a 5-metre diameter antenna, a signal receiver, an image processor and an image analyzer at the Royal Observatory Headquarters, and a remote display at the Airport Meteorological Office.

4.3 The image processor utilizes a dedicated microprocessor for data processing and distribution. All processing functions are carried out automatically according to a pre-defined schedule.

4.4 As signals are received, the imagery is shown on a video monitor and simultaneously stored on a hard disk.

4.5 After reception, sectorized areas are prepared for animation on the image analyzer and the remote display.

4.6 Black and white hard-copies of an imagery are made from a laserfax recorder.

4.7 The digital data is transferred from the hard disk to a magnetic tape for archival.

4.8 WEFAX (LR-FAX) pictures can be displayed on a video monitor after processing by a PC-based LR-FAX image processor and reproduced on a facsimile recorder.

NOAA APT ground reception system

4.9 A block diagram of the NOAA APT ground reception system is shown in Figure 2.

4.10 The VHF transmission from the NOAA polar orbiting satellite is received via an omni-directional two-turn helical antenna.

4.11 The radio signal is amplified and fed into a receiver which demodulates and outputs the subcarrier to a decoder, a facsimile recorder and a audio cassette tape recorder.

4.12 The decoder digitizes the analogue signal for storage and for display on a video monitor.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 The feasibility to incorporate satellite data as input to the in-house Limited Area Models will be examined.

5.2 The development of display facilities to enable convenient integration of satellite data with other data for the purpose of short-range forecasting will be pursued.

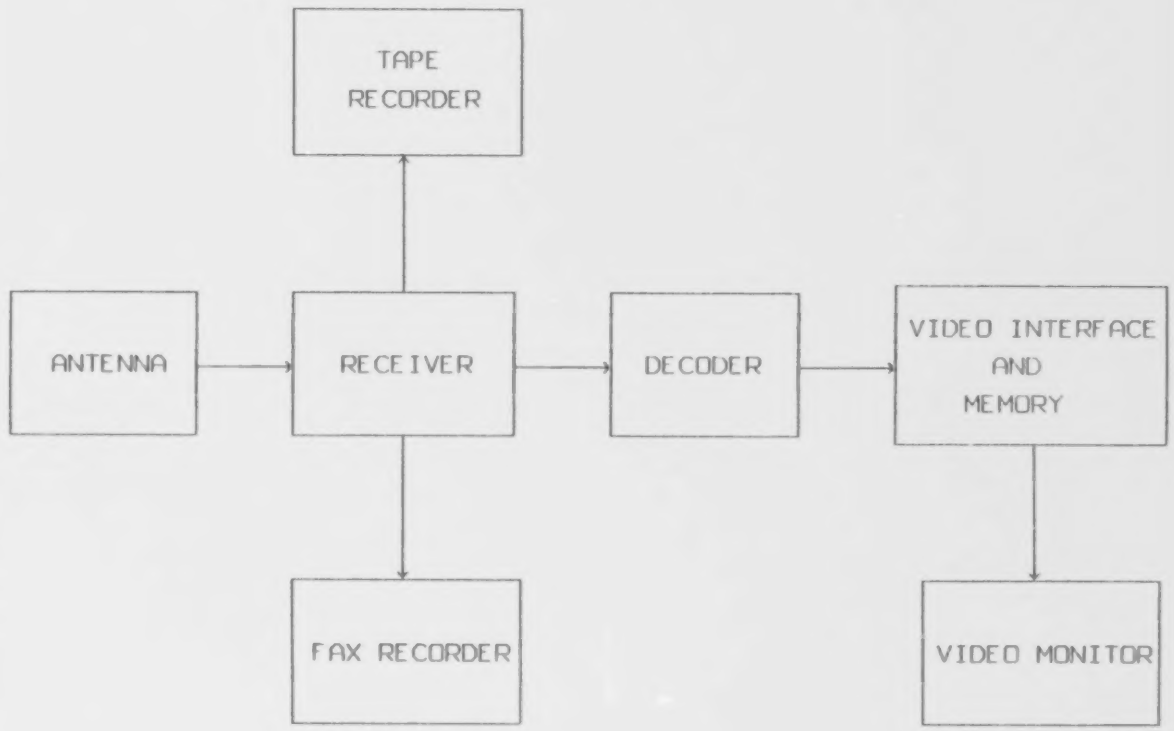


FIG. 2 BLOCK DIAGRAM OF THE NOAA APT RECEPTION SYSTEM

INDIA

India Meteorological Department

PART I Summary of the major highlights of research applications and operational changes

1. INSAT-ID was launched into geosynchronous orbit on 12 June 1990 at 83.0°and made operational on 17 July 1990. It is being used for monitoring atmospheric developments and deriving products such as Cloud Motion Vectors (CMVs), Sea Surface Temperatures (SSTs), Quantitative Precipitation Estimates (QPEs) and Outgoing Longwave Radiation (OLR). Disaster Warning System (DWS) has also been switched over to INSAT-ID from INSAT-1B.

PART II Major research and development in the applications of satellite data, derived products and services

2.1 APT satellite data in respect of monsoon depressions were analysed to identify their different phases of evolution. These depressions are seen to be associated with well organized convective cloud clusters and curved lines defining their cloud system centres in the neighbourhood of cloud clusters. Satellite imagery furnished useful information on formation, movement and intensification of monsoon depressions.

2.2 Using INSAT-1B radiance data for the years 1986-1988, mean monthly rainfall was estimated for the monsoon season and the deviation calculated for individual years. From the mean fields it is seen that there are two areas of heavy rainfall, one in the east Central Bay of Begal and another over the Southeast Arabian Sea of Kerala Coast with the minimum over Tamilnadu and Sri Lanka. The whole pattern shows a southeastward shift with the advance of the season. The anomaly pattern of the rainfall indicates strong negative anomalies during the year 1987 and equally large positive anomalies during 1988.

2.3 Using Cloud Motion Vectors data, average monthly flow patterns for April, May, June and July 1988 were derived. The change of flow patterns at the onset of the monsoon is clearly brought out.

2.4 Using fractional cloud cover data, the low frequency oscillations during the southwest monsoon season of 1986 and 1987 were studied. The time latitude seasons indicate a regular northward movement of the cloud maxima starting from the equatorial Indian Ocean to about 30°N with a period of 30 to 40 days. The spectral analysis of this data indicated the periodicity of 30 to 40 days up to 20°N in both years while the period is enhanced to 60 days between 20°N and 25°N in 1987.

2.5 Evolution of the cloud structure as seen in INSAT cloud imageries at different stages of development of monsoon depressions were examined in a few typical cases. The early stage in the genesis of monsoon depression was found to be associated with a long zonal band whereas the intensive stage was characterized by an organized globular dense overcast in which the centre of circulation was clearly revealed by spirals, close to the edge of the overcast.

2.6 An unusual development of the tropical cyclone was studied during the period 29 January to 4 February 1987 using INSAT-1B satellite imagery. Initial genesis was seen to be spawned by cross-equatorial surges and mechanical subsidence occurring in the relatively cloud free area between deep convective cloud masses. Subsequent intensification was favoured by high sea surface temperatures and suitable synoptic settings. The presence of a dry slot in the western/southwestern side in its intense stage and elongation of associated cloud mass northeastwards towards the later part of its life indicated its increasing interaction with sub-tropical westerly flow which eventually led to its complete dissipation over the sea itself.

2.7 Analysis of percentage cloud cover over the Indian Ocean shows that intensity of the Southern Hemisphere Equatorial Trough is inversely related with the activity of the southwest monsoon over India.

2.8 INSAT-1B satellite imagery was also used to study the intensity of the 25 May 1985 Bangladesh cyclone during its various stages of development. The peak wind veolcity and the tidal wave agreed reasonably well with the intensity derived with the help of satellite pictures.

PART IV System for satellite applications in current operational use

4.1 The India Meteorological Department is utilising the INSAT-1 satellite system for providing meteorological support to the operational weather forecasts. Earth cloud cover data are provided by utilising very high resolution radiometer (VHRR) operating in the visible and infra-red channels at a resolution of 2.75 km in the visible and 11.0 km in the infra-red. The system is designed to provide half hourly data for full earth disc along with sector scans for limited areas once every six minutes.

4.2 One hundred receivers of the Disaster Warning System (DWS) have been commissioned in two southern coastal states of India for direct reception of warning about the natural disasters due to cyclones in 1986. These stations continued to provide useful services in 1990. Warnings disseminated through them were helpful to the State Governments in taking timely action against the impending disaster. Fifty more DWS receivers are being installed in coastal areas of West Bengal, Orissa, North Andhra Pradesh and Gujarat.

4.3 INSAT-1D imagery is now available in near real-time basis at 20 Secondary Data Utilisation Centres (SDUC) located in the various forecasting offices of the country. A new scheme of Meteorological Data Dissemination (MDD) is being put into operation in which it would be possible to receive FAX Charts, satellite imagery and meteorological data through teleprinters. In this connection a total of 23 stations are being established.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 The INSAT-1 series is to be replaced in the 1990s by the second generation of INSAT satellites (INSAT-II). The first satellite of INSAT-II series is expected to be launched by the end of 1991/January 1992. The basic design of INSAT-II satellites would be similar to the existing satellites of INSAT-I series although there would be some improvements.

5.2 The Very High Resolution Radiometer (VHRR) on board INSAT-II will have improved capabilities compared to the VHRR on the existing INSAT-I series of satellites. The major improvements will be in terms of resolution in the visible and IR channels and three modes of operation. The INSAT-II VHRR will have a resolution of 2.0 km in the visible and 8 km in IR as against 2.75 and 11 km in INSAT-I series. The modes of operation will result in getting earth images covering: (a) 20'E to 130°E and 55°N to 55°S; (b) 20°E to 130°E and 45°N to 45°S; and (c) 20°E to 130°E and any 20° in the N-S direction at the user's discretion. The meteorological ground segment for the utilisation of INSAT-II data will be upgraded by the end of 1991 beginning of 1992.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6. CMVs derived operationally are being subjected to quality control checks and are validated against the synoptic flow patterns. These CMVs data are being further used to monitor the onset of monsoon and development of vortices in the Arabian Sea and Bay of Bengal. The gradients in the field of SSTs derived through INSAT IR data are helpful in monitoring the progress of monsoons. Satellite based inferences of tropical cyclone location and intensity are found to be very helpful for the operational forecasters in monitoring and forecasting the cyclones.

PART VII Other items (references, publications and names of scientist in charge, etc.)

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Johri, A.P. and Onkari Prasad, 1990, 'Interaction of Southern Hemisphere Equatorial Trough with the Southwest Monsoon Circulation During Severe Drought Years', Mausam 41, 4, 597-602.

Kelkar, R.R and Rao, A.V.R.K., 1990, 'Interannual Variability of Monsoon Rainfall As Estimated From INSAT-1B Data", Mausam, 41, 2, 183-188.

Mandal, J.C., Kalsi, S.R., Veeraraghavan, K. and Halder, S.R., 1990, 'Some aspects of Bay of Bengal Cyclone of 29 January to 4 February 1987', Mausam, 41, 3, 385-392.

Prasad, K., Kalsi, S.R. and Datta, R.K., 1990, 'Wind and Cloud Structure of Monsoon Depressions', Mausam, 41, 3, 365-370.

Prasad Sant, Khanna, P.N., Rao A.V.R.K. and Kelkar, R.R., 1990, 'Satellite Derived Monthly Average Wind Fields over the Indian Ocean in April to July 1988'. Mausam, 41, 3, 445-450.

Rao, A.V.R.K., Bohra, A.K. and Rao, V. Rajeshwara, 1990 'On the 30-40 Day Oscillations in Southwest Monsoon: A Satellite Study", Mausam, 41, 1, 51-58.

Veeraraghavan, K. and Bahuguna, G.K., 1990, 'A Study of the Bangladesh Cyclone of May 1985 as seen from INSAT satellite imagery', Mausam, 41, 3, 403-408.

IRELAND

Irish Meteorological Service

PART I Summary of the major highlights of research applications and operational changes

1. No major operational changes or research applications.

PART II Major research and development in the applications of satellite data, derived products and services

2. No major research and development in the area of satellite data.

PART III A description of techniques development and applications of satellite data, derived products and services

3. Application of derived products: SATEM and SATOBs (Cloud Motion Winds) are used in the Automatic Data Extraction and Analysis for our NWP.

PART IV System for satellite applications in current operational use

4. SDUS with two stores and displays for general forecasters' use in the Central Analysis and Forecast Office. SDUSs at two airports for aviation forecast use.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. PDUS under consideration.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6. No verification/performance statistics available.

PART VII Other items (references, publications and the names of scientists in charge

7. Research/NWP:

Dr. P. Lynch
Meteorological Service
Glasnevin Hill
DUBLIN 9
Ireland.

General Forecasting: T. Sheridan
Meteorological Service
Glasnevin Hill
DUBLIN 9
Ireland

Aviation Forecasting: P. A. Lyons
Meteorological Office
Shannon Airport
County Clare
Ireland

ITALY

Italian Meteorological Service

PART I Summary of the major highlights of research applications and operational changes

Operational facilities

1.1 During 1990 a major refurbishment of the system for METEOSAT and NOAA reception and processing, installed at the National Meteorological Centre (NMC) of the Italian Meteorological Service, Rome, has been initiated. The refurbishment includes the addition of two MicroVAX computers for off-line processing and the complete redesign of an integrated SDUS/DCP/MDD station.

1.2 The DCP network (10 operational stations) performed as nominal. A further 50 DCPs, to be deployed during 1991-1992 have been commissioned.

1.3 According to EUMETSAT programmes, an MDD uplink station was installed at NMC and has been operational since April 1990.

1.4 The verification of data link for ERS-1 FD data distribution over the GTS has been completed and co-ordinated with ESA/ESRIN and the UK Meteorological Office. A major decision was the adoption of WMO X.25 protocol.

Applications

1.5 The international TOVS Processing Package, version 3 (ITPP-3) has been successfully installed on an IBM 3090/120 mainframe and profiles are retrieved operationally. The possibility of using ECMWF profiles as a first guess have been investigated. TOVS data have been also used to perform a quality control of the National Ozonometric Network. Further development in this area is under study.

1.6 The use of AVHRR for calculating the radiation budget at the air-sea interface has been investigated.

PART II Major research and development in the applications of satellite data, derived products and services

TOVS processing

2.1 The possibility of improving the performances of ITPP by selecting a proper first guess profile compared with the internal statistical data set has been investigated. Experiments over the Mediterranean area using different profiles have been performed. First results have shown that the use of profiles derived from the ECMWF 6-hour forecast substantially improved the performance of the retrieval scheme, showing marginal differences compared with the retrievals obtained using first guess profiles derived from the ECMWF analysis.

2.2 In addition to temperature and humidity profiles, total ozone content from IR radiances is also retrieved by means of ITPP. Total ozone values derived from satellite observations have been compared with the

ground-based measurements of the Italian Meteorological Service by means of Dobson and Brewer spectrophotometers. A good agreement between the total ozone amounts have been recorded. The possibility of an operational use of satellite observations for validation and quality control of ground-based measurements is under investigation.

Air sea interactions

2.3 The surface energy budget over the sea has been computed by means of AVHRR derived SST and ECMWF analysis fields. The algorithm for computing turbulent fluxes has been derived from bulk approximation, assuming constant eddy coefficients and albedo. A split window technique has been used for the correction of AVHRR data. The best split-window algorithm was chosen according to the best comparison with the SST obtained from ships. A method for comparing satellite data (average surface values) with ship data (point values) has been developed. The validation of surface energy budget computed using satellite data and ECMWF analysis fields is carried out by comparing the obtained results with values of surface energy budget computed from ship data.

PART III A description of techniques development and applications of satellite data, derived products and services

Systems

Satellite data reception

3.1 During 1990 a major refurbishment of the PDUS and HRPT systems for METEOSAT and NOAA reception and processing (called ANDROMEDA system), installed at the National Meteorological Centre of the Italian Meteorologial Service has been initiated. The refurbishment includes the addition of two MicroVAX for offline processing.

3.2 As far as the digital reception chains are concerned, the two front end computers, for METEOSAT and NOAA reception, will be backed by two MicroVAX 3800 computers, all systems connected via the ETHERNET link. One of the two MicroVAX will be devoted to research and development applications of satellite data and will be connected to a graphical work station VDS, 64 Mbytes RAM; the other will be devoted to non-real-time operational production, distribution of products to remote users and archiving operations. The two front ends will be left for data acquisition, preprocessing and presentation of real-time products (such as Cloud Top Height and animation of sequences).

3.3 On the SDUS side, a new Integrated SDUS/DCP/MDD station (ISDUS) has been developed in-house, with the capability of receiving simultaneously WEFAX, DCP and MDD data.

3.4 The station is based on a network of PCs and it is equipped with a graphical controller, 14 Mbytes RAM, 135 Mbytes mass storage, capable of animating up to 54 images, 512 x 512 pixel, allowing zooming, panning, colour coding and other image handling facilities.

3.5 The MDD part of the station allows the selection of messages and maps to be received, displayed, printed or stored. It is also possible to retrieve stored messages for printing. The structure of this integrated station is shown in Figure 1.

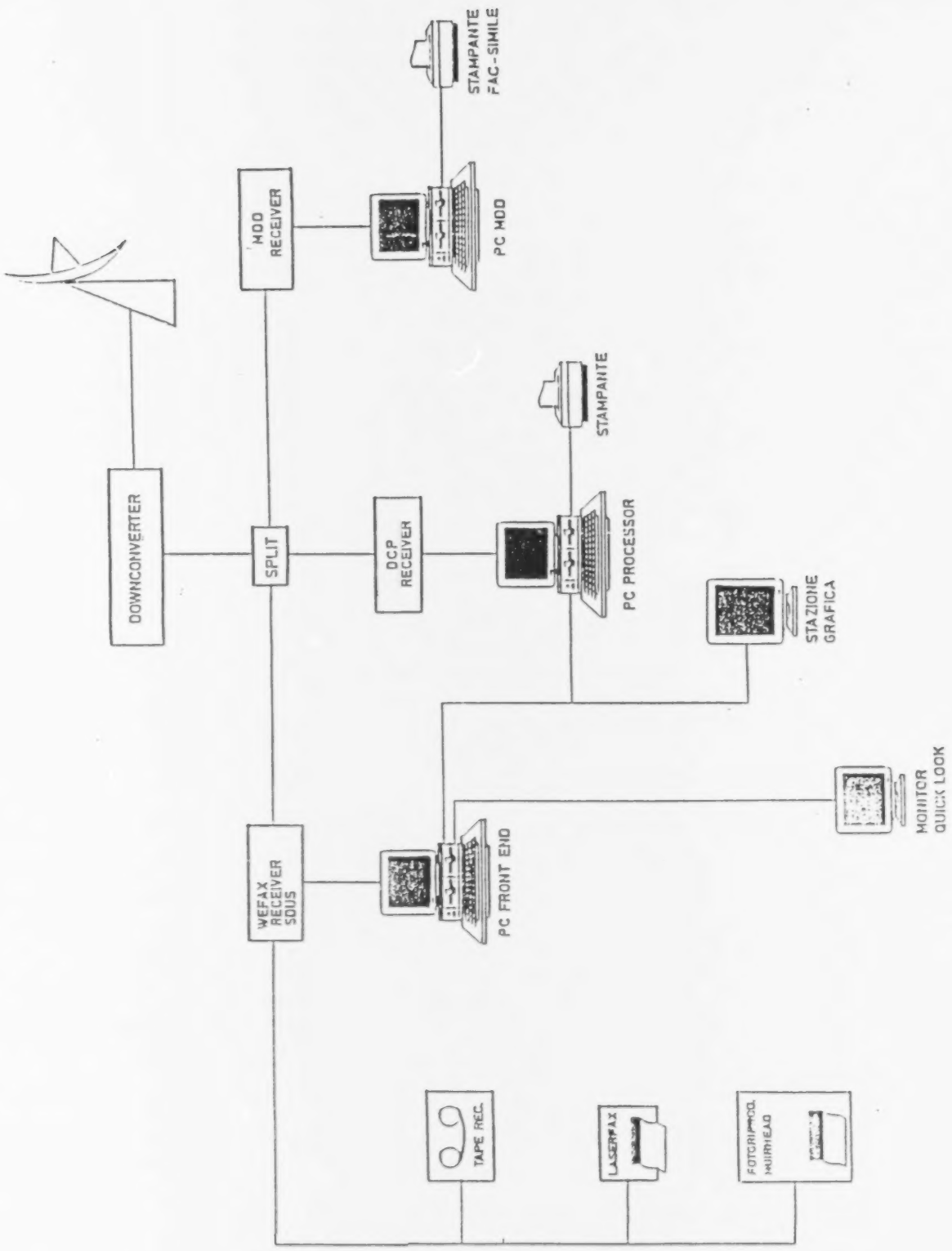


Figure 1: Layout System SDUS/DCP/MDD

3.6 A first prototype of the integrated SDUS/DCP/MDD station will be installed at NMC by end of March 1991.

DCP data

3.7 The specifications for a "second generation DCP station" have been frozen and 50 DCPs have already been commissioned and will be deployed during 1991-1992.

3.8 Major improvements for the future stations will be the addition of four more sensors (visibility, sunshine duration, electrical discharges, snow depth) and the possibility of working both in a full and semi-automatic way, allowing the insertion of visual information in the SYNOP message.

MDD station

3.9 According to EUMETSAT programmes the Rome uplink station has been installed at NMC and it has been operational since April 1990. The station is connected to the message switching system of the Rome RTH and is routinely transmitting alphanumeric data according to a provisional schedule to be defined by January 1992.

ERS-1 data distribution

3.10 The specifications of data link for ERS-1 FD data distribution over the GTS has been completed and co-ordinated with ESA/ESRIN and the UK Meteorological Office. A major decision was the adoption of WMO X.25 protocol. The connection between ESRIN and the Rome RTH has been implemented. The start of operations is expected by May 1991.

Applications

3.11 The following images from processed satellite data have been produced, to be included in a monthly climatological bulletin:

(a) METEOSAT

- monthly mean of total cloud cover, in percent, every three hours, plus daily average;
- daily soil thermal excursion, every ten days;
- albedo, every ten days;
- Apparent Thermal Inertia, every ten days

(b) NOAA

- Normalized Vegetation Index, every ten days;
- Sea Surface Temperature, every ten days;

3.12 All maps produced over Italy and surrounding seas, at pixel level.

PART IV System for satellite applications in current operational use

Operational facilities

4.1 The facilities utilized at the Italian Meteorological Service for exploiting satellite data are the following:

- PDUS and HRPT stations (ANDROMEDA system), for METEOSAT and NOAA data reception and processing, located at the NMC in Rome;
- a SDUS also located in Rome;
- 49 SDUSs located at any other peripheral meteorological office;
- remote terminals (FAX) of the SDUSs, at various sites;
- ten DCPs located at various sites, all over land.

PDUS station

4.2 The PDUS station is inclusive of the following sub-systems:

(a) receiving system, based on a 5 m diameter parabolic antenna and devices for digital signal handling;

(b) computer systems, based on a PDP 11/44 CPU with a 2 Mb central memory, floating point processor, three array processors for dedicated tasks, two tape units (10 Mb each) for supporting the operation of the animation device, line printer console, video terminals and a quick-look device for monitoring the incoming data;

(c) mass storage (two disk units, 122 Mb each) to collect the B format images acquired in the last 32 hours plus a selection of A formats;

(d) two hard copy devices: one for operational use (dry silver paper), the other for selected high quality prints (wet chemical) development;

(e) animation device, which is the core of the whole station; this device calls in sequence up to 32 images, 256 x 256 pixels (or 8 images 512 x 512 pixels). The sequence is repeated on a movie-loop, and automatically updated with the last image acquired, every half hour. The operator has various possibilities to select the position of the TV frame within the images resident on the mass storage, to select resolution, scale factors, speed of the movie-loop, to apply false colouring etc. The animation device is connected to two work stations, one in the operators' room, the other controlled by forecasters. The movie-loops may be recorded on a video cassette system.

The HRPT station and ISIDE system

4.3 The HRPT station is part of a system called ISIDE (Interactive System for Image Data Elaboration), also used for off line operations and for development, due to the odd peak loads of NOAA data acquisition.

4.4 The system is composed of the following sub-systems:

(a) a receiving system, based on a parabolic steering antenna, 3.5 m diameter, and devices for tracking and digital signal handling;

(b) a computer system based on a PDP 11/44 with 1.5 Mb Central Memory, floating point processor, two tape units. Three disk units (10 Mb each), line printer console and video terminals;

(c) a mass storage (two disk units, 122 Mb each) for storing the last 12 min NOAA passes and over 400 images 512 x 512 pixels;

(d) one electrostatic plotter printer with special software for simulating hard copies, besides the ordinary utilities on any plotter and printer;

(e) one photorecorder for high quality hard copies (wet chemical development);

(f) two graphic pictorial interactive systems for image analysis: one based on a VDS 7001 system, 2 Mb RAM, the other on a TESAK 501, 256 Kb RAM

The system includes a video cassette recorder and a link to the PDUS for access to the mass storage on PDUS.

4.5 The functional scheme of the ANDROMEDA system is shown in Figure 2.

The SDUS stations

4.6 Various types of SDUSs are operational at the Italian Meteorological Service; the oldest were implemented in 1983 and are equipped with dry silver photorecords and a b/w monitor only for the visualization of the incoming images. They are bound to be improved, see Part III "Satellite data reception". More recent stations have been implemented, with the capability of animation, false colouring, zooming and hard copy devices.

Remote terminals

4.7 Twelve remote terminals are at present operational, connected to the Rome SDUS to receive METEOSAT images via a dedicated telephone line. All are equipped with a dry silver photorecorder and a TV monitor. The reconversion of functions and structure of the remote terminals is planned. (see Part V "Systems")

DCP network

4.8 Ten stations have so far been installed. Their location is shown in Figure 3, together with the position of conventional stations operating at present (about 100). Each DCP is measuring eight parameters: atmospheric

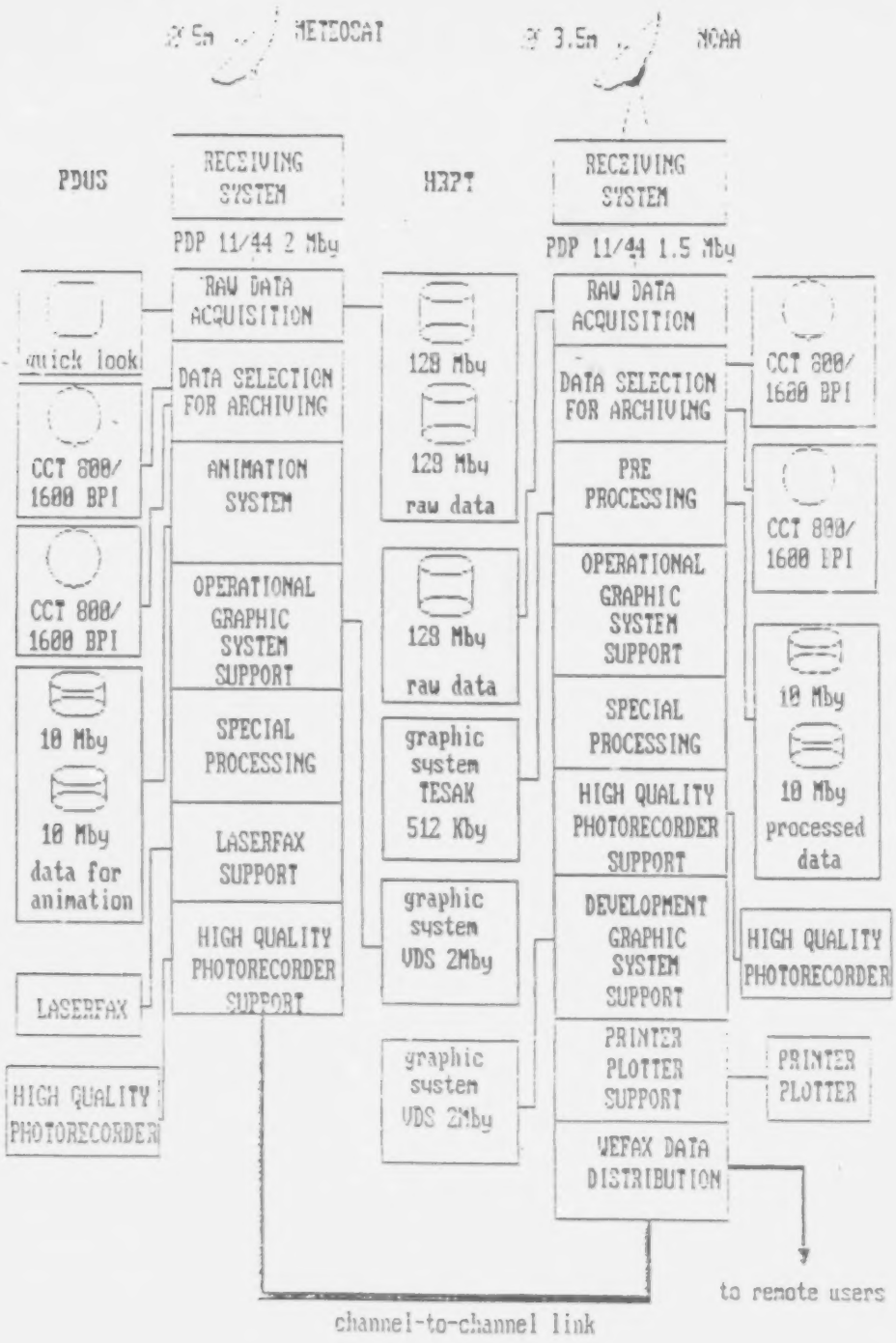


Figure 2: Scheme of the ANDROMEDA system

Figure 3

pressure, wind speed, wind direction, air temperature, air humidity, preciptation, soil temperature and global solar radiation.

Operational products

4.9 The following operational products from processed satellite data are available.

- animation of METEOSAT images;
- remapping of METEOSAT images in stereographic projection;
- Cloud Top Height from METEOSAT images, every half hour;
- TOVS retrieved profiles

Archiving

4.10 Satellite data are archived at NMC according to the following strategy:

(a) METEOSAT data:

- 30 days archive: BV and BI formats every 3 hours;
  AI format every 3 hours;
- permanent archive: window over Italy in IR every 3 hours;
  two AI format/day;
  everything during selected periods;

(b) NOAA data:

- 10 days archive: AVHRR: 2 pass/day;
- permanent archive: AVHRR: selected periods and situations;
  TOVS: raw data and retrievals.

All data are available on CCTs and hardcopy.

PART V Plans for future operational systems for satellite applications in current operational use

Systems

5.1 Short-term development of the ANDROMEDA system at NMC will include:

- replacement of front end computers of both PDUS and HRPT with more updated systems (VAX family);
- connection with the mainframe computer of the NMC for a fast data and product exchange;
- improvement of the archiving facilities be means of the acquisition of EXABYTE cassette and optical disk units.

On the SDUS side the oldest SDUSs will be replaced by the new integrated stations ISDUS.

5.2 The remote terminals, described in Part IV "Remote terminals", will be updated and reconverted for receiving from NMC, in WEFAX format, psuedo-images from processed satellite data, e.g. CTH maps, or high resolution sub-frames of NOAA images.

5.3 As far as the use of DCP is concerned, the first set of 50 DCPs already commissioned will be installed by the end of 1992. A further set of more than 60 stations will be commissioned.

Applications

5.4 The main items for development of new applications have been identified in the following areas:

TOVS processing:

5.5 The development of TOVS processing is considered along the following lines:

- optimization of retrieval coefficient for the Mediterranean areas;
- use of AVHRR data for better determination of SST and declouding;
- use of TOVS output, e.g. precipitable water, as input data in the fine mesh Limited Area Model;
- use of TOVS retrieval for a better determination of the cloud top height derived from METEOSAT images;
- use of TOVS-derived total ozone content for validation and calibration of the National Ozonometric Network.

Precipitation and heavy convective clouds identification

5.6 A merging of satellite and radar data will be developed for the identification of heavy convective clouds and subsequent linear evolution for nowcasting will be developed. The application of algorithms for determination of rainfall intensity and amount in an operative procedure will be investigated.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

Contacts:
- Dr. Paolo Pagano, Head of Satellite Branch
- Dr. Luigi De Leonibus, Head of Operational Product Branch

JAPAN

Japan Meteorological Agency (JMA)

PART I Summary of the major highlights of research applications and operational changes

Operational Change from GMS-3 to GMS-4

1.1 GMS-4 was launched on 6 September 1989 as the successor to GMS-3. The operational observation was taken over from GMS-3 by GMS-4 on 4 December 1989. GMS-3 was moved to 120 degrees E to serve as a back-up satellite to GMS-4.

Observation and Dissemination

1.2 The High Resolution Facsimile (HR-FAX) dissemination was replaced by the Stretched VISSR (S-VISSR) dissemination on 1 April 1988 aiming at real-time and quantitative utilization at user stations. The LR-FAX (Low Resolution Facsimile) was renamed as WEFAX (Weather Facsimile). The hourly VISSR observation for full-disk images was initiated on 5 January 1989. The normal operation schedule of observation and dissemination is shown in Figure 1. The additional images observed on a 6-hourly basis (e.g. W0) are used for the derivation of Cloud Motion Winds (CMWs).

Improvement of Height Assignment Table for GMS High-level Wind

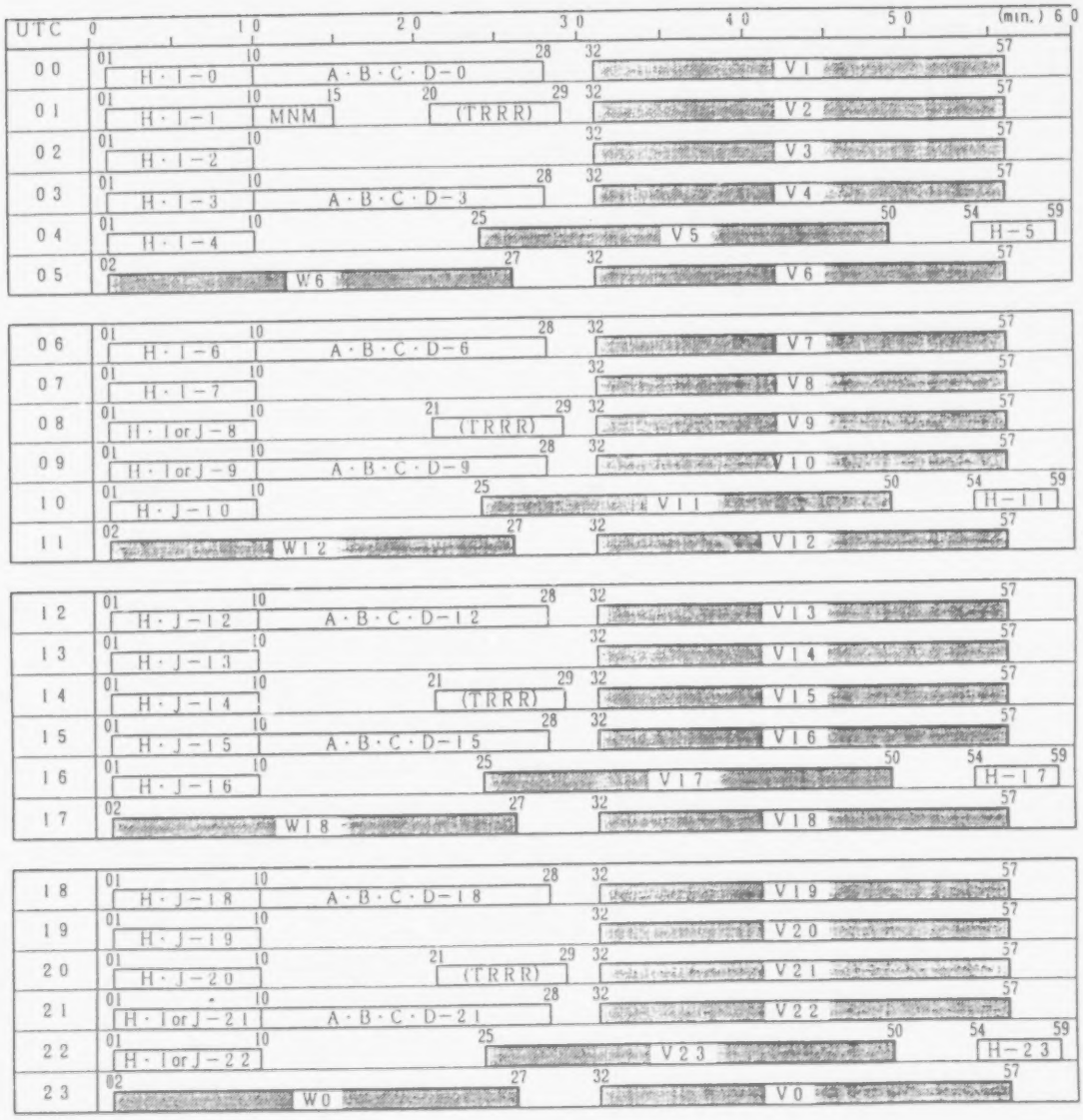
1.3 In order to improve the accuracy of GMS high-level Cloud Motion Winds (CMWs), the height assignment table determined in 1981 was revised on 1 April 1990. The details are described in Part VI.

Cloud Type Classification by Split Window Data and Its Applications

1.4 Clouds can be classified into optically thick clouds and optically thin clouds by the brightness temperature difference (BTD) between 11 μm and 12 μm. The BTD is very small (nearly 0) for optically thick clouds such as cumulus and cumulonimbus clouds, while it is large for optically thin clouds such as cirrus clouds. Utilizing the BTD and brightness temperature in 11 μm a simple objective cloud type classification method was developed by Inoue (1987a).

1.5 Cloud climatology from split window data was studied by Inoue (1989) over the tropical Pacific. Cirrus type clouds were found to be a major cloud type over the tropical Pacific. East-west contrast of major cloud types is significant over the tropical Pacific during northern winter. The clouds over the western tropical Pacific mainly consist of deep convective clouds and cirrus clouds, while clouds over the eastern tropical Pacific mainly consist of low level stratocumulus.

1.6 Analysis of convective activity was improved by the use of split window data. The index of convective activity was refined by the use of optically thick clouds while discarding cirrus type cloud by the split window clouds type classification method. Furthermore, the split window is very effective to derive sea surface temperature (SST) and index of total



ABBREVIATIONS

VISSR OBSERVATION
Vnn: VISSR OBSERVATION OF nnZ
Wnn: OBS. FOR WIND ESTIMATION

TRRR: TRILATERATION RANGE AND RANGE RATE

WEFAX DISSEMINATION
A~D: 4-SECTORIZED INFRARED FULL-DISK
H~J: IR, VIS AND ENHANCED IR POLAR-STEREOGRAPHIC COVER THE FAR EAST AREA
MNM: MANUAL AMENDMENT WITH TEST PATTERN

** IN CASE OF 15 MIN. SPECIAL TYPHOON OBSERVATION, SCHEDULE OF 03&04GMT WILL BE AS FOLLOWS.

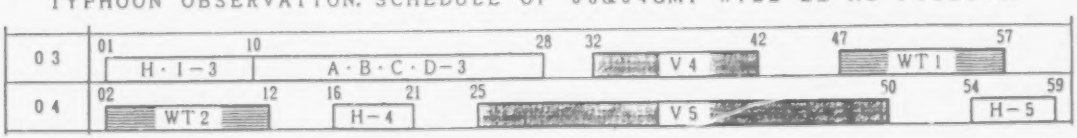


Fig. 1 Observation and Dissemination Schedule (as from Jan. 1989).

precipitable water. It was found that convective activity is highly related to both water vapour and SST, and water vapour is more clearly related to convective activity than SST.

1.7 The rainfall area delineation was also improved by the use of split window data (Inoue, 1987b). The rainfall area by relatively shallow cumulus can be detected by the split window cloud type classification. No-rain areas by cold cirrus can be effectively discarded by the method.

PART II Major research and development in the applications of satellite data, derived products and services

Monitoring of the Global Climate System

2.1 By utilizing the Grid Point Values of GMS-4 IR radiance data, the global climate system is being monitored by the Long-range Forecast Division, Forecast Department, JMA.

2.2 Consecutive five-day averages are computed from the three-hourly measurement data at each 2.5- by 2.5-degree grid for equivalent black-body temperature (TBB) and at each 1.0- by 1.0-degree grid for high-cloud amount, respectively. Using these five-day averages, monthly means (consecutive 30-day averages; for August 35-day average) and seasonal means (three-month averages) for TBB and high-cloud amount, and high-cloud amount anomalies from nine-year averages (from 1978 to 1986) are prepared.

2.3 The data are being used for monitoring the monsoon activities, the interannual variations (e.g., ENSO) and the intraseasonal variations ranging from 30 days to 60 days in the tropics, and the activities of the frontal zone around East Asia.

MOS-1 Satellite Data Utilization

2.4 With regard to the application of Japanese Marine Observing Satellite (MOS-1) data, a project for making SST map retrieved from the satellite is being performed by joint research program of the National Space Development Agency of Japan (NASDA) and the Meteorological Research Institute (MRI). A new satellite multi-sensor multi-channel algorithm for SST was developed by combining Visible and Thermal Infrared Radiometer (VTIR) and Microwave Scanning Radiometer (MSR) data.

Deriving Cirrus Information Using the Visible and Near-IR Channels

2.5 To improve a monitoring technique for deriving cirrus information using the future series of NOAA-AVHRR radiometers, the radiation at the top of a model atmosphere-ocean system is computed where cirrus clouds are assumed to be composed of hexagonal ice crystals (columns and plates). The effects of orientation of ice crystals are also estimated. The computational results show the feasibility of deriving the thermodynamic phase of cloud using multi-channels that include 1.61 μm wavelength region which is proposed as a new channel.

Validation Experiments for Oceanic Phenomena found in SAR Images

2.6 Images taken by SAR on board the space shuttle in 1984 were investigated. By comparing the AVHRR infrared images, it was shown that features found in SAR images of the Japan Sea are strongly related to ocean current shear and eddies.

2.7 Several cruises by the JMA research vessels are planned to make simultaneous observations with both European and Japanese ERS-1 SAR observations. These experiments will provide sea truth data such as ocean waves, small scale surface roughness, ocean current, and atmospheric parameters, which are essential for analyzing oceanic phenomena observed by SAR. These cruises will be carried out around Japanese Islands several times per year.

PART III A description of techniques development and applications of satellite data, derived products and services

Operation of SAREP

3.1 The Meteorological Satellite Center (MSC), JMA has disseminated on an operational basis satellite reports on tropical cyclones (SAREP, WMO international code FM 85-IV, FM 85-IX) since November 1988 when a tropical cyclone is located in the region between 100°E and 180°E in the northern hemisphere. MSC disseminates information on the location of the tropical cyclone under the heading TPPW20 RJTD every three hours, and information on the intensity including the location under the heading TPPW21 RJTD every six hours.

Dissemination of Low-level Cloud Motion Winds in a Typhoon Area

3.2 Low-level Cloud Motion Winds (CMWs) in a typhoon area have been derived on a routine basis from 15-minute interval images around 04 UTC since the 1988 typhoon season. The plotted wind data are sent by TELEFAX from Meteorological Satellite Center to Forecast Division of the JMA Headquarters.

Special Experiment Concerning Typhoon Recurvature on Unusual Movement (SPECTRUM)

3.3 The Special Experiment Concerning Typhoon Recurvature on Unusual Movement (SPECTRUM) was organized by ESCAP/WMO Typhoon Committee to obtain enhanced meteorological observational data required for studies by Typhoon Committee Members on the movement of tropical cyclones in the western North Pacific with a view towards improving operational tropical cyclone forecasting. JMA participated in the SPECTRUM field experiment in twofold : one was to provide the functions of the experiment center and the other was to make intensive observations.

3.4 During the experiment period, August and September 1990, six Intensive Observation Periods (IOPs) were settled with the total duration of 17 days. During each IOP, JMA made enhanced observations, which included the low-level wind vectors in the vicinities of a typhoon from 15-minute interval consecutive GMS cloud imagery.

Satellite-derived Indexes of Precipitation Intensity

3.5 Satellite-derived Indexes of precipitation intensity (SIs) were designed for estimation of hourly precipitation intensity by the use of visible (VIS) and infrared (IR) channel data of GMS. The SIs were calculated at every grid (one grid space is 5 km x 5 km) and were graded in 16 intensity levels corresponding to the radar intensity levels. Their region consist of 700 x 300 grids covering the whole of the Japanese Islands and their circumference.

3.6 Basically, the SIs are calculated by the multiple regression analysis between GMS (VIS and IR) data and the digital radar data. Coefficients in the regression equation are determined prior to the SIs calculated by substituting the GMS grid data into the regression equation. These coefficients are replaced by the latest set if they satisfy certain conditions. There are two types for the regression equations. The bi-spectral method (using VIS and IR data) is adopted in the daytime. VIS data are corrected to uniform by local solar zenith angle. The mono-spectral method (using IR data and processed IR-parameters) is adopted in the nighttime.

3.7 The SIs have been processed automatically at every hour according to the operational schedule in the MSC since March 1989 and disseminated to C-ADESS (Center-Automated Data Editing and Switching System) within a few minutes after the VISSR observation. They are utilized domestically for very short-range weather forecasting as the supplementary data outside the effective coverage of meteorological digital radar observation network.

The Cloud Amount Anomaly Chart

3.8 Three kinds of high cloud amount anomaly charts have been produced in each period of five days, a month and three months since July 1988. Normals are derived from five-day mean cloud amount data for 13 years (February 1978 - December 1990). These charts are disseminated to the Long-range Forecast Division of the JMA Headquarters by the coded digital facsimile, and are provided to monitor convective activities in the tropics as well as circulations in middle latitudes.

Precipitation Estimation Algorithm for the Algorithm Intercomparison Programme of the Global Precipitation Climatology Project (GPCP)

3.9 The first experiment of the GPCP was conducted over Japanese area in 1989. JMA participated in this project to examine the new algorithm, which is available to estimate the frontal type rainfall in middle latitudes. The precipitation was estimated by linear discriminant analysis with the hourly cloud parameters derived from GMS infrared data. The difference between this algorithm from another is that a cloud parameter related to the mechanism of the frontal type rainfall was added to the general cloud parameters, such as cloud temperature and cloud amount.

PART IV System for satellite applications in current operational use

Data Utilization at JMA

4.1 GMS imagery data are distributed to the JMA Headquarters and relevant local offices for use in their services. The main distribution routes and the data utilization are as follows:

JMA Headquarters

(a) High-resolution imagery

High-resolution imagery data are transmitted from MSC on the JMA's microwave circuit to the Headquarters. The data are taken into the satellite imagery handling equipment in the Forecast Department. Weather, oceanographic, and sea ice forecasters use the stored imagery data being reproduced on CRT displays.

(b) Low-resolution imagery

Low-resolution imagery data are also sent to the Headquarters, and mainly used for watching weather conditions by such means as computer loop movies.

Local installations

4.2 WEFAX direct receivers are equipped to receive low-resolution imagery at ten forecast centers, four Marine Observatories and six Aviation Observatories/Stations. The received data is used in a similar way to that in the Headquarters.

4.3 In addition to the imagery, secondary derived data are distributed to the JMA Headquarters and relevant local offices through the JMA's land line network and Automated Data Editing and Switching System (ADESS). The distributed products include satellite cloud information charts, index of precipitation intensity, cloud motion wind vectors, VISSR grid point data (e.g., cloud amounts, mean cloud-top temperature, etc., at each 0.5-degree mesh) and sea-surface temperature.

Use of Forecast Data on GMS Data Processing at Meteorological Satellite Center

4.4 In MSC, the following three types of forecast data are received from the Numerical Prediction Division of JMA. The grid point data of 5-degree mesh in latitude and in longitude which cover the whole of GMS 200 km area are used for the data processing of cloud motion winds, sea surface temperature, cloud amount and TOVS. The grid point data of 0.2-degree mesh over the Japan area and that of about 125 km mesh over the far east area have been used for the various kinds of satellite image analyses (e.g. satellite cloud information chart) to support the short-range forecast since November 1990.

Application to Marine Meteorological Data Collection of in situ Observations

4.5 JMA is collecting marine meteorological and oceanographic data from six observation/ research vessels of JMA with the DCP system.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

Plans for GMS-5

5.1 GMS-5 is under development and is scheduled for launch in early 1994. GMS-5 is the successor to the current operational satellite, GMS-4. The new satellite will have additional observation spectral bands with minor changes in the visible spectrum as summarized in Table 1.

Table 1 Observation Spectral Bands

Observation Spectral bands	GMS-4	GMS-5
visible	0.5 to 0.750	.55 to 0.90
infrared (thermal)	10.5 to 12.5 11.5 to 12.5	10.5 to 11.5
infrared (water vapor)	-	6.5 to 7.0

(units: micro-meter)

GMS-5 will further have an experimental search and rescue equipment to relay distress signals.

Radar Observation on Board

5.2 JMA is collecting shipboard weather radar data from meteorological observation ships of JMA via the GMS regional frequency band.

5.3 The diagram is shown in Figure 2. Summary of the specification is as follows:

Number of DCPs	:	2
Frequency	:	One of the GMS regional channels (Time division transmission)
Bit rate	:	1200 bps
Modulation	:	4-QPSK
Data	:	Echo intensity, height of echo tops, accumulated hourly radar precipitation

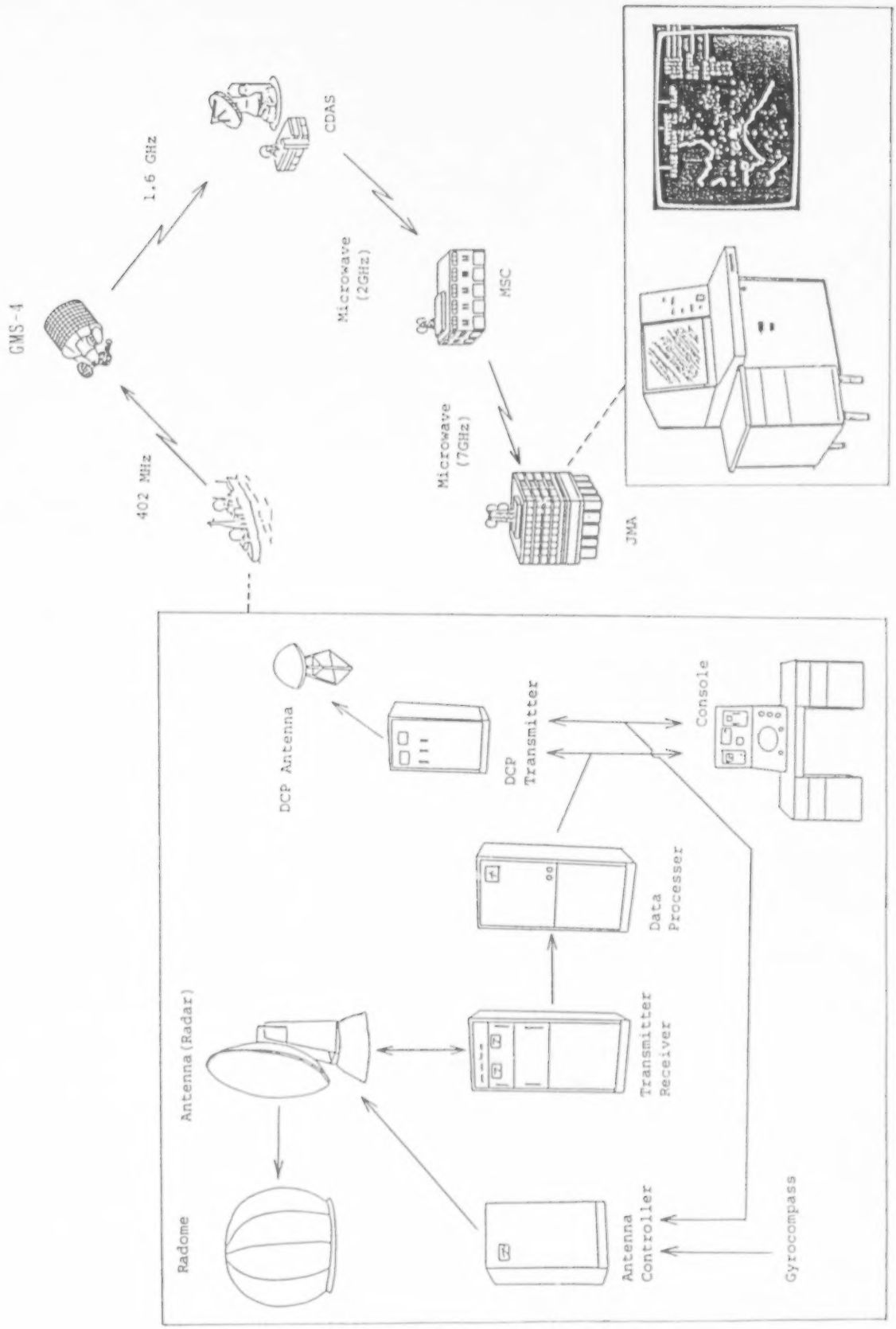


Fig. 2 System Diagram of Ship's Radar Observation.

PART VI Validation and verification of satellite data and derived products

The Height Assignment for GMS High-level Wind

6.1 Representative heights were assigned to the resultant high level Cloud Motion Winds (CMWs). Those representative heights were determined on the basis of statistical level-of-best-fit between CMWs and radiosonde winds.

6.2 The table of statistical wind representative heights was revised on 1 April 1990. The old table was determined using one month data representing four seasons from 1980 to 1981. In order to improve the accuracy of high level CMWs, the table was revised using the data for 1988. The revised table was statistically determined every ten degrees in latitude for each month. The comparison results between CMWs and radiosonde winds from 1988 are shown in Fig. 3. It is shown that the CMWs are evidently improved.

Low-level Cloud Motion Wind Derivation in a Typhoon Area from GMS Short-time Interval Images

6.3 In order to estimate the ocean surface winds in a typhoon area using the Cloud Motion Winds (CMWs), low level CMWs have been derived on a routine basis from 15 minute interval images since the 1988 typhoon season. The 15 minute interval images are useful for deriving CMWs in a typhoon area compared with the usual interval of 30 minutre images and they make it possible to derive the low level CMWs 200 km from the centre of the typhoon.

From the comparison of low level CMWs with ship observed winds, the following are found:

(a) The mean speed of the low level cloud motion winds is almost equal to that of ship observed winds.

(b) The ship observed wind flows about 30 degrees on average towards the centre of typhoon relative to cloud motion wind direction for the winds at the distance of 200 km to 600 km from the centre.

The plotted wind data are sent to the Forecast Division of JMA by TELEFAX.

Status of VISSR Observation

6.4 The operational observation was moved from GMS-3 to GMS-4 on 4 December 1989. GMS-4 has been stationed at 140°E. GMS-3 has been stationed at 120°E as a back-up satellite. The VISSR observation status of GMS-4 from January through December 1990 is shown in Table 2.

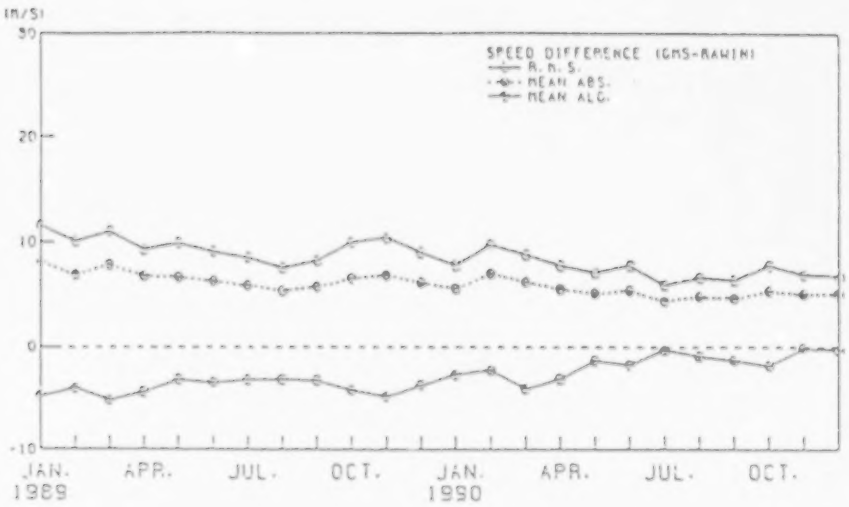


Fig. 3 The speed difference between the high-level CMWs and radiosonde winds

Table 2 VISSR Observation Status of GMS-4 in 1990

Month	Number of Scheduled Observations	Number of Active Observations
January	868	856 (98.6%)
February	784	766 (97.7%)
March	800	794 (99.3%)
April	810	809 (99.9%)
May	868	858 (98.8%)
June	840	822 (97.9%)
July	868	844 (97.2%)
August	868	867 (99.9%)
September	780	780 (100.0%)
October	828	827 (99.9%)
November	840	828 (98.6%)
December	868	857 (98.7%)

PART VII Other items (references, publications and the names of scientists in charge (etc.)

7.1 Publications

Inoue, T. 1987: A cloud type classification with NOAA-7 split window measurements. J. Geophys. Res., 92, 3991-4000.

Inoue, T., 1987b: An instantaneous delineation of convective rainfall areas using split window data of NOAA-7 AVHRR. J. Meteorol. Soc. Japan, 65, 469-481.

Inoue, T., 1989: Features of clouds over the tropical Pacific during northern hemispheric winter derived from split window measurements. J. Meteorol. Soc. Japan, 67, 621-637.

Inoue, T., 1990: Deriving relationship of sea surface temperature and water vapour amount to convection over the western tropical Pacific revealed from split window measurements. J. Meteorol. Soc. Japan, 68, 589-606.

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Takeuchi Y.: A location algorithm of ARGOS data collection platform.

Takeuchi Y. and Y. Yoshizaki: Evaluation and improvement of the accuracy of sea surface temperature derived from the operational processing of TOVS data.

Harada T.: On enhancement displaying of GMS image.

H. Tanaka and H. Miyoshi: The performance technique of the operational job schedule and the automated-command of JOB.

Abe Y., I. Nishimori, H. Senda and T. Imaizumi: Accuracy of the satellite-derived index of precipitation intensity and its representative characteristics.

Doi K., H. Uchida and S. Naito: Revised height assignment for high-level cloud motion winds derived from satellite imagery.

Asano T.: Use of NOAA data on marine and fisheries in function.
Miura S.: Improvement of telemetry watching function.

Meteorological Satellite Center, 1990: Technical note of Meteorological Satellite Center (in Japanese with English Summary), No. 21, 87pp.

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Kigawa S.: Influence of the polar atmosphere on the image mapping using earth edge data.

Mita A.: Visiting the University of Wisconsin and the National Oceanic and Atmospheric Administration.

Tada K.: A usage of wind data derived from GMS in the upper tropics.

Ando Y.: Added information by man-machine interactive operation of the SCIC.

Chubachi K.: An estimation of surface wind profile within the range of 200 km from a typhoon center using GMS images.

Sakurada M.: The representation of Cb cluster's life cycle using TBB data and radar data.
Tomita T.: Scintillation observed on the GMS communication link.

KENYA

Meteorological Department

PART I Summary of the major highlights of research applications and operational changes

1.1 This report summarizes the current status of the satellite receiving equipment within the Kenya Meteorological Department (KMD) and various aspects in applications of satellite technology in meteorology as an aid to weather forecasting and drought monitoring.

1.2 It also touches briefly on the future plans for the satellite facilities within KMD.

PART II Major research and development in the applications of satellite data, derived products and services

2. A lot of scientific research is presently being carried out by both the department's personnel and the other end users (mainly from the remote sensing centres within the country and the university students) using satellite derived information. Meanwhile, there have been a number of requests for the NOAA images but due to our limitations in applications software we have not managed to honour all the requests. We hope to do so in the near future.

PART III A description of techniques development and applications of satellite data, derived products and services

IMAGE DATA-BASE

3.1 The HRPT and PDUS facilities are currently capable of receiving and processing images on all available channels from both NOAA satellites and the METEOSAT.

HRPT STATION

3.2 The HRPT station was installed in Nairobi in May, 1988 with an expected areal coverage from latitude 22 degree North to 25 degree South and longitude 12 to 60 degree East, allowing for excellent coverage of Eastern Africa.

3.3 Presently, it is capable to acquire images on channels 1 - 5 plus the TIPS (e.g. TOVS etc.) which are archived daily on magnetic tapes for local use as an internal data-base and to other remote sensing centres in the country. These tapes are later on sent to ESA for storage on a weekly basis.

3.4 Little has been done on its applications. This is all awaiting the development of the appropriate applications software.

PDUS STATION

3.5 The PDUS station was installed early 1990 and is now receiving full imagery from the METEOSAT satellite every half hour.

3.6 The station is fitted with a video display unit with software for displaying images.

3.7 Using these facilities, it has been possible to get colour enhanced images and blow-ups.

3.8 The pictures are particularly useful in aiding analysis of conventional data especially in detecting the position of the ITCZ, the frontal system together with the cyclones.

PART IV System for satellite applications in current operational use

4.1 The HRPT processed images for the NDVI Centres and FAO in their various projects such as the early warning system for food security.

4.2 The Meteosat images are expected to be useful in rainfall estimation and as data-base for future use.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 Establish KMD as a regional centre for image acquisition and pre-processing of satellite data. Microwave link for disseminating both raw and processed satellite images to other remote sensing centres within Kenya.

5.2 Develop application software for processing the satellite images for various end users.

5.3 Acquire ancther PDUS system which will be mainly dedicated to research and training at the RMTC Nairobi. It will also be used by the Drought Monitoring Centre on a day-to-day basis.

MADAGASCAR

Météorologie Nationale

PART I Summary of the major highlights of research applications and operational changes

1. The Directorate of Meteorology and Hydrology has an APT/WEFAX satellite reception station (SDUS) which was installed in 1985 in Antananarivo. Satellite applications have considerably improved the quality of meteorological analyses and related forecasts. The forecasts prepared by the Meteorological Service are intended for aeronautical, marine and hydrological users and particularly the general public.

PART II Major research and development in the applications of satellite data, derived products and services

2. The Service has not yet developed any applications in these fields.

PART III A description of techniques development and applications of satellite data, derived products and services

3. Satellite imagery from all the channels is used simultaneously for the careful interpretation of phenomena on different scales. In particular, V.F. Dvorak's technique has often proved effective in solving tropical cyclones monitoring and forecasting problems.

PART IV System for satellite applications in current operational use

4. The Dornier station is made up of a parabolic antenna trained onto METEOSAT, one omni-directional antenna for receiving the NOAA or METEOR satellites, an interactive control/command centre permitting manual or automatic operation, one printer using photosensitive paper, one color display console with a refresh memory and image processing (contrasts, false colours, enlargement, decoding, and animation). The station can grid NOAA/APT images automatically with respect to latitude and longitude.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. The station will be equipped this year with a unit permitting it to function with the METEOSAT DCP system.

PART VI Validation and verification of satellite data and derived dproducts used in operations, including performance statistics

6. No applications have so far been developed.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

7. The address for any correspondence is as follows:

Mr. Vincent Randriamampianina
Direction de la Météorologie et de l'Hydrologie
Boite Postale 1254
Antananarivo 101
Madagascar

MOROCCO

Météorologie Nationale

PART I Summary of the major highlights of research applications and operational hanges

Estimating snow cover using a digital satellite data-processing system.

1.1 In several countries, snow is an important asset. Snowmelt has an impact on agriculture, hydroelectric power generation, domestic water supply and flood control. The economy of Morocco is predominantly agricultural and relies heavily on hydroelectric power.

1.2 Several methods have been used for estimating snowmelt flows, and the advantages and disadvantages of these are expounded in available literature, such as the "Handbook on the principles of hydrology" (Gay, 1973), etc. The Martinec-Rango snowmelt runoff model (SRM) simulates and predicts daily flow in mountain basins where snowmelt is a dominent factor in runoff. The SRM is based on the degree-day method, i.e. the assumption that snowmelt runoff is directly proportional to air temperature, which is an index of the snow cover- atmosphere energy budget.

1.3 Daily estimates of snow cover during snowmelt, combined with parameters characterising the basin and daily temperature and precipitation data, are essential inputs to the SRM. The model has been applied to the Tillouguit basin in the Moroccan Atlas Mountains, which covers approximately 2,544 km^2 and rises from 1,050 to 3,400 m.

PART II Major research and development in the applications of satellite data, derived products and services

Method for estimating snow cover

2.1 Estimates of snow cover can be made visually or using aerial imagery for basins whose area is less than a few tens of km^2. Martinec et al (1983) recommended using satellite data because they are easy to handle. The method for estimating snow cover was developed using the PCI system for satellite image processing.

(a) Configuration of the PCI system

- 1 IBM PC/AT
- 1 1.2 Mb diskette drive
- 2 hard discs, (30 and 80 Mb)
- 1 high-resolution visual display unit
- 1 1600 bpi magnetic tape reader
- 1 digitisation table
- 1 Summagraphique plotter
- 1 EPSON 1050 printer

MSS data for 13 February 1986

2.2 LANDSAT MSS (multispectral scanner) data for 13 February were purchased from Italy (the Earthnet Program Office), where the receiving station is located. Band 2 (0.56-0.68 µm) was read out on magnetic tape and stored on hard disc using EASI software (Engineering Analysis and Scientific Interface). The Tillouguit basin, with its rivers and three elevation zones (1,050-2,050, 2,050-2,550, 2,550-3,400 m) were digitised using a 1:250,000 topographic map and VECDIG (vector digitizing) software. Since the resolution of one pixel and the total number of pixels is known, both for each elevation zone and for the basin as a whole, the area of each elevation zone could be calculated.

2.3 To distinguish bare ground from snow, a threshold value equivalent to 67 times the value of each band 2 pixel was established on the basis of visual scrutiny of the bare ground-snow interface on the MSS picture for 13 February.

AVHRR data

2.4 Although their resolution is inferior to that of LANDSAT, the NOAA/AVHRR satellites do make two passes every 24 hours over every part of the globe; for this reason, AVHRR data are useful in making daily snow cover estimates. During the snowmelt in 1986, only cloud-free areas were selected. Owing to the fine resolution of the MSS data, the threshold of 67 was used to determine the band 1 threshold for the AVHRR data for 12 February 1986. Since the percentage of each elevation zone under snow cover was known from MSS data for 12 February, a threshold for the AVHRR data was established.

2.5 A count of 39 was established for the 12 February scene. To take account of the daily variation in solar angle, the thresholds for other areas selected were standardized. The attached flow-chart shows the procedure adopted for estimating the snow cover in the Tillouguit basin.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 Despite the difficulties in acquiring representative data, the results obtained are satisfactory for the 1979 snowmelt. A coefficient of determination (R2) of 0.84 and an absolute difference of 0.53% were found between the observed and simulated flows. Using basin parameters estimated during 1979, the SRM was applied to the Tillouguit basin for the snowmelt in March 1986. A coefficient of determination (R2) of 0.72 and an absolute difference of -6% were found between the observed and calculated flows.

5.2 Use of an image processing system facilitates snow cover assessment and relieves the analyst of the difficult task of photo interpretation. The latter was used for the 1979 snowmelt.

5.3 Several simulations should be made for normal hydrological years before the basin's mean parameters can be determined. The passage from the simulation stage to forecasting should be possible when the forecast variables (temperature and precipitation) are available.

PART VII Other items, (references, publications and the names of scientists in charge, etc.)

7.

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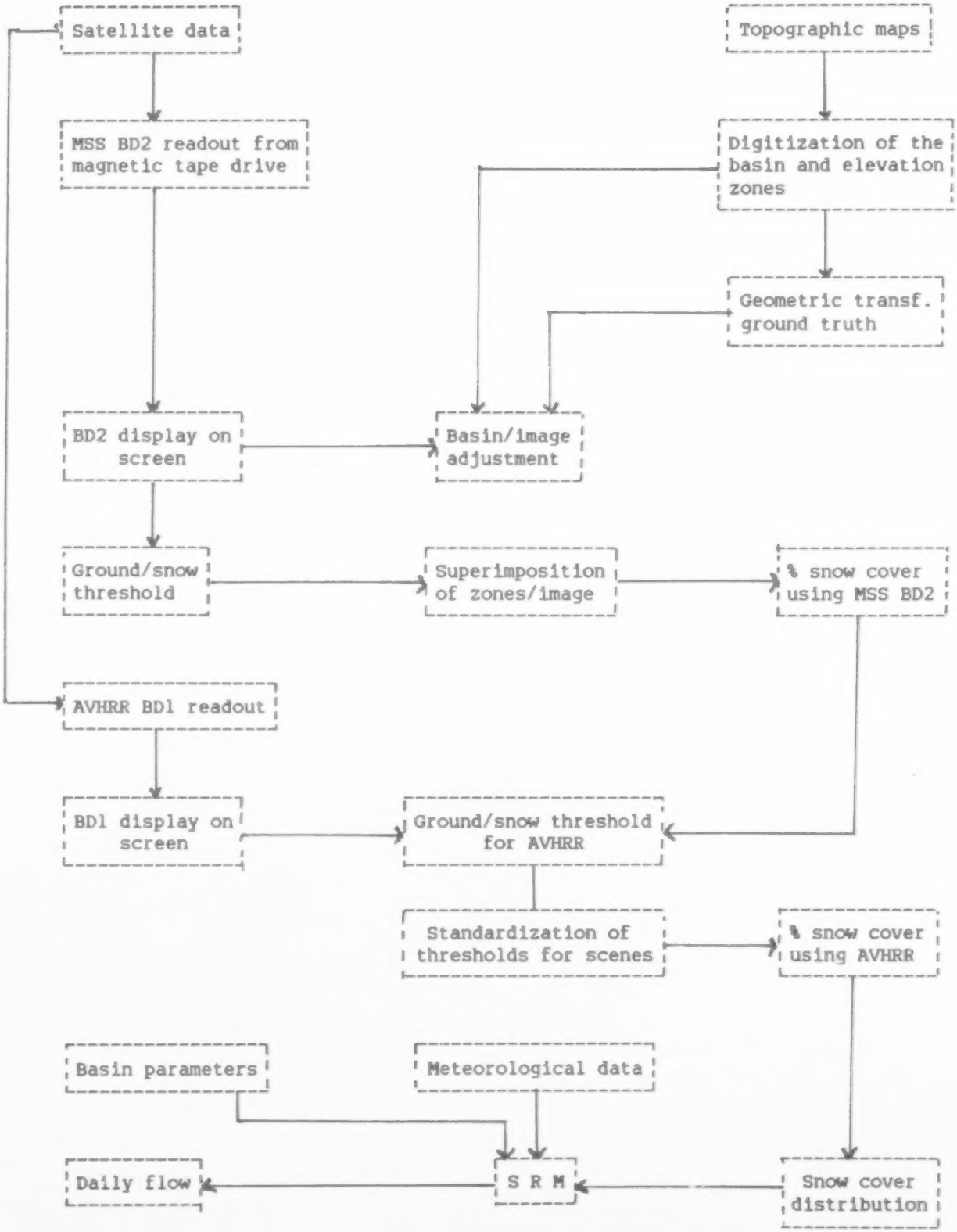

Figure 1 -Method for evaluating snow cover used on the Tilloquit basin in the

UNION OF MYANMAR

Department of Meteorology and Hydrology

PART I Summary of the major highlights of research applications and operational changes

1. This report summarizes the satellite applications in the functional area of transmission of satellite data through direct broadcast modes (APT and WEFAX). The TELEX/ALDEN APT receiver which was installed in June 1973 is still operationally receiving WEFAX but it does not properly receive the APT of polar-orbiting satellites. During the reporting period, the NESDUS-70, which was installed in 1986 became unserviceable for lack of spare parts. The satellite pictures are used in the daily weather analysis and forecasting (public, aeronautical and marine).

PART II Major research and development in the applications of satellite data, derived products and services

2. No specific research projects were undertaken during 1990. However, individual researchers were using satellite pictures for their studies.

PART III A description of techniques development and applications of satellite data

3. The C.F.O. (HQ) receives processed WEFAX pictures from GMS-3. There are four types of pictures namely Infrared, Visible, Water Vapour and cloud top height.

PART IV System for satellite applications in current operational use

4. At times satellite pictures are sent to the Main Aviation Meteorological Office (Mingaladon Airport). For public forecasting, a daily 06Z/09Z WEFAX picture is televised. All the forecasts for Public, Aviation and Marine are mainly dependent on the availability of WEFAX pictures.

PART V Plans for future operational ystems for satellite applications to meteorology and operational hydrology

5. The department's plan is to try to obtain a Primary Data User Station (PDUS) or Secondary Data User Station (SDUS) geostationary meteorological satellites. The interested domain of research with SDUS/PDUS will be cold cloud duration CCD and monsoon rainfall over Myanmar.

NORWAY

Det Norske Meteorologiske Institutt

PART I Summary of the major highlights of research applications and operational changes

1.1 Implementation of a new system for handling of operational meteorological satellite information, MISAT.

1.2 Combined presentations of advanced NOAA and Meteosat derived products and numerical model output in the MISAT system.

PART II Major research and development in the applications of satellite data, derived products and services

PART III A description of techniques development and applications of satellite data, derived products and services

Further development of routines and (derived) products in the MISAT system.

Improve the analyses and assimilation techniques of TOVS data and simulated ERS-1 data in numerical prediction models. A technique based on the idea of continuous assimilation is under development.

PART IV System for satellite applications in current operational use

4. Local high resolution NOAA (HRPT) and Meteosat (PDUS) receiving stations and processing system are operationally running. Products are distributed to regional meteorological centres. Fully operational systems for NOAA DCPS transmissions and Meteosat DCPs are in use. The MISAT system has been a parallel system during the latter part of the year. A basic idea for the MISAT system is to automatically generate a product data base containing radiometrically calibrated and map-transformed high-resolution images and animation sequences. In addition, numerical model output, geographical grid and land contours are stored in the product database. The MISAT system is able to display merged combinations of the information present in the database.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. Further development of MISAT system and derived products.

- Automatic classifications of surface and cloud characteristics from AVHRR-data.
- Improved regional SST algorithm from AVHRR.
- Integrations of data from other satellites like DMSP and ERS-1 for ice detection.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6. Preparatory activities for combinations and evaluations of ERS-1 scatterometer wind data and altimeter wave data with in situ and numerical model output. Preparatory activities for impact studies of ERS-1 data on numerical predictions.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

- Jens Sunde, MISAT, NOAA - AVHRR and METEOSAT
- Lars-Anders Breivik, ERS-1
- Mariken Homleid, NOAA - TOVS

PHILIPPINES

Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)

PART I Summary of the major highlights of research applications and operational changes

1.1 The Geostationary Meteorological Satellite (GMS) S-VISSR Ground Receiving System of PAGASA resumed operation in May, 1990. During the short period that the system was inoperational, a Low Resolution Facsimile (LR-FAX) receiver was used to receive cloud imagery.

1.2 GMS S-VISSR imagery were regularly received daily for operational use in the provision of meteorological services to aviation, shipping and the general public.

1.3 There were no operational changes in 1990.

PART II Major research and development in the applications of satellite data, derived products and services

2. Nil

PART III A description of techniques development and applications of satellite data, derived products and services

3.1 The basic technique still being used is the Dvorak Models for estimating the intensity of tropical cyclones

3.2 A combination of Visible and IR images are used in determining cloud systems, areas of convection, synoptic weather system, location of tropical cyclone and determining its size, intensity and movement.

3.3 The derived products available are the cloud wind vector received from JMA through GTS plotted on 850 hpa and 200 hpa charts for streamline analysis.

3.4 A colored satellite picture is also used in television weather broadcast.

PART IV System for satellite applications in current operational use

4.1 The basic GMS S-VISSR Ground Receiving System utilises the standard type NEC Satellite Data Utilization System (NESDUS) 210 Series.

4.2 Significant features of the system among others, are picture display for various analysis such as:

- Pseudo color display
- Full disk image and sectorized images

- Enlargement (X1, X2, X4, X1/2)
- Sequential display (36 images)
- Gridding

4.3 Hard copies of the grey scale and colored GMS S-VISSR imageries on thermal paper measuring 20.5 cm. x 21.5 cm. are in polar stereographic and Mercator projections.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. In the second half of 1991, PAGASA expects to operationalize the NOAA Polar Orbiting Satellite ground receiving facility which will be installed through a grant from the Government of Australia. It is planned to integrate this new system with the existing GMS receiving system. With this enhanced satellite data receiving facility, a special unit is planned to be organized to undertake techniques development and applications of satellite data especially with the TOVS capability.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6. Not yet being undertaken.

PART VII Other items (references, publications and names of scientists in charge, etc.)

Mr. CIPRIANO C. FERRARIS
Deputy Director,
PAGASA
1424 Quezon Avenue
Quezon City,
Philippines

Mr. ELLAQUIM A. ADUG
Chief, Weather Branch
PAGASA,
1424 Quezon Avenue
Quezon City,
Philippines

Mr. EDUARDO M. PARONG
Assistant Chief, Weather Branch
PAGASA
1424 Quezon Avenue
Quezon City
Philippines

POLAND

Institute of Meteorology and Water Management

PART I Summary of the major highlights of research applications and operational changes

1.1 The Institute of Meteorology and Water Management (IMWM) is responsible for weather forecasting, meteorology, hydrology, climatology and water management service and research in Poland.

1.2 The Institute is well equipped for receiving and processing of analogue and digital satellite data from NOAA, METEOR and METEOSAT satellites for meteorology, hydrology, water management, agriculture and environmental studies. The scope of activities referring to satellite meteorology is presented in Part II - VII.

PART II

2.1 The research problems were concentrated on:

- development of the relationship between satellite NOAA AVHRR pictures analysis and flow modeling results;
- the use of satellite data and numerical models' results for precipitation forecast in the mountain area;
- estimation of land surface temperatures from AVHRR data;
- methods for objective satellite NOAA AVHRR pictures analysis;
- estimation of cloud top temperature and cloud cover thickness;
- optimization of the algorithm for vertical temperature and moisture profiles from TOVS/TIP data (NOAA satellites);
- determination of ozone mixing ratio profiles and its total content over Europe, from TOVS/TIP data (NOAA satellites);
- method for determination of cloud effect correction for TOVS/TIP date using AVHRR images (NOAA satellites);
- estimation of global solar radiation for Poland from WEFAX data (METEOSAT geostationary satellite).

PART III A description of techniques development and applications of satellite data, derived products and services

3.1 Satellite data transmitted by NOAA (USA), METEOR (USSR) and METEOSAT (Europe) are received and processed for meteorology, hydrology, climatology, water management, agriculture and environmental protection purposes. Several independent informative systems have been established during 1990.

3.2 Interactive system for registration and processing of AVHRR (Advanced Very High Resolution Radiometer) from NOAA satellites consists of:

- HRPT registrator (Satellite Data Processor);
- IBM-PC/AT, IBM-PC/386 microcomputers connected in LanSmart local network, including EGA, SVGA monitors three Winchester disks (40 MB, 80 MB, 330 MB), RAM 4 MB;

- streamer 60 MB;
- Genius mouse;

The software consists of programmes for:

- transmission errors check;
- AVHRR data radiometric and geographical calibration;
- images processing;
- histogram and bi-spectral histogram evaluation;
- modelling of LuT (Look up Table) characteristics;
- clouds tops temperatures evaluation;
- clouds layer thickness evaluation.

The system is open, new programmes can be easily included.

3.3 Interactive system for registration and processing in real time of HRPT (High Resolution Picture Transmission) data obtained from polar orbiting satellites NOAA (USA) and only for processing SPOT (France) and LANDSAT (USA) satellite data consisting of:

- HRPT receiving station (1700 Mhz);
- IBM-PC/AT microcomputers (two) connected in D link local area network, including EGA monitor, Winchester disk 80 MB, RAM- 7 MB;
- magnetic tape drivers;
- analogue picture photoregistrator (scanner write);
- digitizer of analogue pictures (scanned read).

The software of the interactive system consists of programmes for:

- computing of NOAA satellites positions;
- registration in real time of HRPT data;
- calibration and geographical location of satellite data;
- processing of AVHRR (Advanced Very High Resolution Radiometer) data;
- conversion of SPOT and LANDSAT data into standard form;
- image processing.

The system is open, can be connected to local network and new interpretation software may be simply added by users.

3.4 The hardware system for registration and processing TOVS/TIP digital data in real time from polar orbiting satellites consists of:

- TOVS/TIP satellite receiving station (137 Mhz,VHF-BEACON);
- IBM-PC/AT computer with EGA monitor, Winchester disk 40 MB, 3.7 Mb RAM;
- magnetic tape drivers (two);
- plotter.

The software consists of programmes for:

- computing of NOAA satellite positions;
- registration of TOVS/TIP data in real time;
- calibration and geographical location of HIRS (High Resolution Infrared Radiation Sounder) and MSU (Microwave Sounding Unit) field of view;

- retrieval of temperature and moisture vertical profiles in the atmosphere;
- retrieval of ozone mixing ratio profile and its total content.

3.5 Interactive system for registration and processing of analogue satellite images (APT and WEFAX). The hardware systems for registration in real time and processing of APT images obtained from NOAA and METEOR satellites as well as WEFAX images from METEOSAT geostationary satellite consist of:

- APT receiving station 137 MHz;
- WEFAX receiving station (1700 MHz);
- IBM-PC/AT microcomputer with EGA monitor, Winchester disk 40 MB, IMB RAM;
- four monochromatic TV monitors with additional RAM memory for display of APT and WEFAX images;
- analogue picture photoregistrator;
- digitizer of analogue pictures.

The software consists of programmes for:

- registration in real time of APT and WEFAX images;
- sequential displaying of APT and WEAFAX images one by one, on monochromatic TV monitors;
- animation of WEFAX images on EGA colour monitor;
- modeling of LuT (Look up Table) characteristics.

PART IV System for satellite applications in current operational use

4.1 The satellite receiving stations for weather forecasts requirements are presently working at four branch offices of the Institute of Meteorology and Water Management:

	APT	WEFAX	HRPT	TOVS/TIP	PROCESSING
Krakow	x	x	x	x	x
Warszawa	x	x	-	-	x
Gdynia	x	x	-	-	-
Wrockaw	-	x	-	-	-

4.2 The Satellite Data Processing Center, Satellite Data Interpretation Laboratory at the IMWM - Krakow Branch in Krakow leads research and applications of satellite information for meteorology hydrology, water management, agriculture and environmental studies.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. Computers implementations of prepared methods for operational use:

- operational system for objective NOAA AVHRR pictures analysis;
- retrieval of temperature and moisture vertical profiles;

- retrieval of ozone mixing ratio and its total content over Europe;
- determination of water surface temperature of the Baltic Sea;
- estimation of surface temperature and soil moisture of the river basins in Poland;
- evaluation of clouds layer thickness and clouds tops temperatures;
- measurement of global solar radiation for Poland;
- nowcasting for Warszawa area based on digital METEOSAT data and radar data.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6.1 The results of three hundred temperature and moisture profiles calculated from TOVS/TIP data were compared versus data obtained from seven aerological stations in Middle Europe:

Warszawa, Poznan, Keba - Poland;
Kiev, Lvov - USSR;
Prague - Czechoslovakia;
Lindenber - Germany.

The following statistics were computed

- root mean square errors;
- standard deviations;
- biases;
- correlation coefficients and its dependence on height was determined.

6.2 The results of cloud top temperatures and land surface temperatures estimation were compared versus aerological data from Middle European stations (i.e. stations located in Poland, Germany, Italy, Czechoslovakia, Austria and USSR). Archives files have been constantly updated. Statistical analysis will be performed when the length of the sample reaches the proper size.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

7.1 Publications:

Barariski L.A., Rozemski K., 1990, Determination of the Ozone Mixing Ratio Profiles in the Atmosphere from TOVS/TIP Satellite Data. Ozone in the ATMOSPHERE, A.Deepak, Humpton,USA

Rymarz Cz.,1990, Synoptic Methods and Aspects of the Study of Global Instability of Geostrophic Flow, Journ. Tech. Phys., No. 32,N. 1, pp.51-60, Baranski L. A., Rozemski K., Jankowiak L., 1990, Seasonal Changes of the Spatial Distribution of Ozone Content over Central Europe from TOVS/NOAA data., Advances in Space Research (to be published)

Dyras I., 1990, Clouds Detection on Digital Satellite Pictures., Proceedings of the INTERKOSMOS Conference (to be published)

Bapeta B., 1990, The Algorithm for Computing Geographical Net for NOAA AVHRR Image., Proceedings of the INTERKOSMOS Conference (to be published)

Serafin-Rek D., 1990, Operational System for Clouds Tops Retrieval from AVHRR., Proceedings of the INTERKOSMOS Conference (to be published)

7.2 Names of scientists at the:

Satellite Data Interpretation Laboratory
Institute of Meteorology and Water Management
PL 30-215 Krakow
P.Borowego str. 14

Telephone: (012) 22- 60-33
Telex 0322446 pl,0325211 hm pl
Telefax 22 08 82

Estimation of cloud top temperature and cloud layer thickness from AVHRR data:

- Ms Izabela Dyras
- Ms Danuta Serafin-Rek
- Ms Bozena Bapeta

Methods for cloud cover from AVHRR NOAA pictures analysis:

- Ms Izabela Dyras
- Ms Danuta Serafin-Rek

Methods of pattern recognition applications to satellite images objective analysis:

- Ms Izabela Dyras

Development of the relationship between AVHRR images analysis and flow modeling results:

- Ms Izabela Dyras
- Mr Marek Jerczyriski

7.3 Names of scientists of the

Satellite Data Receiving and Processing Center
Institute of Meteorology and Water Management
PL 30-215 Krakow
P.Borowego str. 14

Telephone (012) 11-67-98,11-38-44
telex 325514 hm pl

Optimization of algorithm for vertical temperature and moisture profiles from TOVS/TIP data:

- Mr Leskaw A. Bararíski
- Mr Krzysztof Rozemski

Determination of ozone mixing ratio profiles and its total content over Europe from TOVS/TIP data:

- Mr Leskaw A. Bararíski
- Mr Jerzy Mrugalski
- Mr Krzysztof Rozemski

Determination of the Baltic Sea surface water temperature from AVHRR data:

- Mr Leskaw A. Baranski
- Mr Jerzy Mrugalski
- Mr Piotr Struzik

Estimation of surface temperature and soil moisture of the river basins in Poland from AVHRR data:

- Mr Leskaw A. Bararíski
- Mr Piotr Kmiecik
- Mr Jerzy Mrugalski

Method for determination of cloud effect correction from TOVS/TIP data using AVHRR data:

- Mr Leskaw A. Bararíski
- Mr Piotr Kmiecik
- Mr Krzysztof Rozemski
- Mr Piotr Struzik

Estimation of global solar radiation from METEOSAT data:

- Mr Leskaw A. Bararíski
- Ms Halina Chrzanowska

The registration of satellite data:

- Mr Leskaw A. Baranski
- Mr Jerzy Mrugalski
- Mr Piotr Kmiecik
- Mr Piotr Struzik

Interactive processing of satellite data:

- Mr Leskaw A. Bararski
- Mr Jerzy Mrugalski
- Mr Piotr Kmiecik
- Mr Piotr Struzik
- Mr Krzysztof Rozemski

7.4 Names of scientists of the:

Central Weather Forecast Office
Institute of Meteorology and Water Management
PL 01-673 Warszawa
Podlesna str.61

Telephone: 34-16-51, 34-18-92
Telex 814331, 816228 hm pl

- Mr Ryszard Klejnowski - Application of satellite images for weather forecast developed for aircraft communication

- Mr Jan Kaczmarski - Synoptic Interpretation of satellite APT and WEFAX pictures

- Mr Czesiaw Rymarz - Evolution of macro scale cloudiness systems on satellite pictures

NOTE:

The scientists working for satellite meteorology and operational hydrology are open for international co-operation referring to:

- development of new methods
- fellowship and post graduate programme exchange for scientists
- training courses
- software exchange for IBM/PC microcomputers

SINGAPORE

Meteorological Service

PART I Summary of the major highlights of research applications and operational changes

1.1 A new satellite reception system was installed in early 1990 to receive stretched VISSR transmissions from the Japanese Geostationary Meteorological Satellite (GMS). An existing system to receive data from NOAA polar orbiters is integrated into the new system, so that automatic reception and processing of high resolution data simultaneously from both GMS and NOAA satellites is possible in near-real-time. This capability is achieved by the use of two main processors and a dual antenna system. Additionally, these processors are connected to a mainframe by high speed links to permit further processing.

1.2 A high resolution local workstation is available for image analysis processing and application studies. It is planned to utilise existing software and software to-be-developed for both research and operational use.

PART II Major research and development in the applications of satellite data, derived products and services

2. Currently, extraction of temperature and humidity profiles from TOVS data is being experimented with, for the SE-Asia region.

PART III A description of techniques development and applications of satellite data, derived products and services

3.1 Received satellite imagery is used operationally to forecast weather conditions for aviation, shipping and the public.

3.2 Application techniques to produce image enhancement (both colour and monochrome) and animated sequences have been introduced.

3.3 Archiving of data to support operational requirements and research will be undertaken.

PART IV System for satellite applications in current operational use

4.1 Both GMS reception every hour and receipt of NOAA transmissions is possible independently.

4.2 A high resolution local workstation and ample peripheral devices facilitate the input of data and generation of operational products.

4.3 The present software can be used for efficient image processing and estimation of several meteorological parameters.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. It is planned to derive cloud vector winds for operational use and to attempt assimilation of data for input in NWP models.

PART VI Validation and verification of satellite data and derived dproducts used in operations, including performance statistics

6. It is hoped to introduce this in the near future.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

7. Contact:

Mr. Paul Lo Su Siew
Director
Meteorological Service
P.O. Box 8
Singapore Changi Airport
Singapore 9181

SUDAN

Meteorological Department

PART I Summary of the major highlights of research applications and operational changes

1.1 In 1972, APT ground receiving equipment was installed at the Telecommunications Centre of Khartoum NMC, making it possible to receive visible satellite pictures of clouds from NOAA-TIROS as well as the METEOR Series of polar-orbiting satellites. Ten years later in May 1982, a combined new APT/WEFAX station was installed at the Forecast Office at Khartoum International Airport. This has been in operation to date with a video system for displaying images added in 1985.

1.2 In 1988, a Digital High Resolution Rainfall Estimator was also installed at the same forecast office at Khartoum Airport.

1.3 Then in November 1989, the APT/WEFAX system was modified to include a Data Receiving System (DRS) and to date some ten Data Collection Platforms (DCPs) have been installed country-wide and therefore the collection of meteorological data from the stations is being effected via the geostationary meteorological satellite (METEOSAT).

1.4 In short, NMC Khartoum has been equipped with the following systems:

- APT/WEFAX (1982)
- Digital High Resolution Rainfall Estimator (1988)
- DCPRS (November 1989)

PART II Major research and development in the applications of satellite data, derived products and services

2.1 Regarding the applications of satellite data, NMC Khartoum is capable of receiving APT pictures and processed WEFAX data from polar orbiting satellites and the METEOSAT respectively. Visible Infra-red, water vapour and cold cloud tops are received and these are used as aids in the study of the evolution and movement of dust-generating convective systems in the Sudan and adjacent areas and therefore their use as analysis and forecasting tools are being demonstrated.

PART III A description of techniques development and applications of satellite data, derived products and services

3.1 The Rainfall Estimator is doing a fine job. As part of a collaborative effort between the Sudan Meteorological Department and the University of Reading in England, the rainfall estimates derived from this technique are being calibrated using ground truths (conventional rainfall gauges data). The estimates are highly relevant to the objectives of the Sudan Early Warning System (EWS) for which the mapping of rainfall areas is significant for agriculture.

3.2 For some time in the past, NMC Khartoum has been facing the problem of lack of proper accommodation on the Global Telecommunication System (GTS). Now with the installation of the DRS at the NMC and the 10 DCPs country-wide, real-time collection of meteorological data for both research and operational purposes is a reality. At the same time, the dissemination of NMC data to other centres outside is foreseen. The number of the DCPs is to be increased onwards.

PART IV System for satellite applications in current operational use

4. Through the operational use of satellite pictures, it is possible to identify areas of convective clouds as well as the Intertropical Convergence Zone (ITCZ) popularly known in the Sudan as the Intertropical Discontinuity (ITD). Deep convective systems well to the south of the ITD may also be located by use of the video system which shows cloud top heights.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. Plans include:

- Use of satellite pictures in conjunction with radar observations to study precipitation dynamics at the Port Sudan area of the Red Sea in the Sudan. This may await the renovation of the radar system there.

- A capability of data distribution is envisaged.

- So far hydrology has not been very much involved in satellite applications but the potential of these will be demonstrated when the Flooding Forecasting on the River Nile and its Tributaries Project is inaugurated sometime in the future. The present satellite systems now in operation may need to be enhanced.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6. Currently not applicable.

PART VII Other items (references, publications and the names of scientists in charge)

Ali, A.M.A. : 1986-Forecasting of dust-generating convective systems in the Sudan with the aid of satellite pictures; Paper submitted for the WMO International Competition for young scientists for the year 1986.

Other Scientists: Mr. A.M.B. Zahran Mr. J.A. Paramena Mr. S.D. Kafi.

SWEDEN

Swedish Meteorological and Hydrological Institute

PART I Summary of the major highlights of research applications and operational changes

1.1 SMHI installed a new processing system for satellite data in 1987. This system is named PROSAT (PROcessing system for meteorological SATelite data). The main contractor for the system was Ericsson Radar Electronics AB. This company delivered the system with TERAGON-CONTEXT AB as the main sub-contractor. PROSAT can be partitioned in three main parts:

- Host computer
- Satellite data reception system
- Image processing system with workstations

1.2 The system is described in Karlsson and Liljas 1990. PROSAT has automatic scheduling and reception of digital data from METEOSAT and NOAA satellites. Images are produced according to operational requirements, stored on a special videodisc and presented on standard geographical areas in near real time for meteorological forecasters at different locations and for oceanographers. The system has capability to allow both operational use and research. At the central office of SMHI there are four main workstations. PROSAT is providing fast processing of multispectral satellite data. A system for real time processing of TOVS data is also included (See Svensson,1989).

1.3 An operational cloud classification based on all channels from the AVHRR of the NOAA-satellites was implemented in 1989. The classified images are used extensively at the so called regional forecast offices responsible for Nowcasting and Very Short Range Forecasting.

1.4 NOAA images are used in operational work in combination with METEOSAT images with higher temporal resolution. Satellite images are displayed together with radar composites and fields from analyses or forecasts of NWP models.

1.5 An increased interest concerning the use of satellite images in hydrological projects is now taking place in such areas as snow mapping, land-use classification and lake area calculation. In oceanography, satellite images are mainly used in research projects. Efforts are concentrated on calibration of LANDSAT TM and MSS data for determining suspended matter in "class two waters", whereas sea surface temperature from AVHRR data is used for circulation studies. The use of AVHRR data for sea ice mapping is operational at SMHI, however, the cloud cover is extensive during the winter period and limits in practice the amount of usable images. Hence, a long term programme is running to prepare the use of SAR data from the ERS-1 satellite to be launched in May, 1991. Sweden will be involved in the calibration/validation and demonstration phase of this satellite under the PIPOR (Programme for International Polar Ocean Research) programme.

1.6 SMHI hosted in June 1988 a symposium on the processing of TOVS-data in Northern latitudes.

1.7 In 1990, the 8th Meteosat Scientific Users' Meeting was held in Norrköping. Around 150 delegates attended the meeting that was arranged by SMHI in co-operation with EUMETSAT.

PART II Major research and development in the applications of satellite data, derived products and services

Meteorology

2.1 Major research activities have been devoted to the automatic multispectral classification of NOAA/AVHRR data. The activities have been reported by Karlsson 1989 and 1990 and Liljas 1988, 1989 and 1990. A detailed description of the model can be found in Karlsson and Liljas, 1990.

2.2 METEOSAT data has been used in studies of rainfall. NOAA/AVHRR precipitation fields have been used as ground truth. METEOSAT vis and IR data has been combined to give the amount and pattern of rainfall over 12 hours. (Karlsson, 1990).

2.3 TOVS processing is not performed operationally at this stage. Data assimilation experiments have been performed. An evaluation of TOVS products has been fulfilled over one year. Forecasts from the SMHI Limited Area Model (+6) have been used as initial guess. The TOVS retrievals have been compared with radiosonde profiles and it was found that the RMS differences were small compared with similar studies.(Liljas and Svensson,1991).

Hydrology

2.4 The hydrological applications has been focused on land-use classification for calculations of runoff and nutrient transport, using LANDSAT TM data. Mapping of lake and flood areas for various hydrological purposes has also been done. These type of investigations are of increasing interest and will be further studied in the future. The AVHRR data has been and will be used to monitor the time evolution of the snow cover in some Swedish mountain areas. The snow mapping is used to increase the quality of the runoff forecasts.

Oceanography

2.5 Within oceanography short term environmental monitoring studies has been undertaken in the Skagerrak and Kattegatt areas of the eastern North Sea. Sea surface temperature and suspended matter are used as tracers for water masses, whose time evolution is followed. Main emphasize is concentrated on river plume evolution in the coastal zone and sea surface circulation of the Skagerrak area. Tests to obtain drift velocities are made, using consecutive satellite images. During 1991 this type of work is also done in the northern Baltic during an intensive interdisciplinary study. For example, ARGOS drifters will be used for dispersion and circulation studies together with the AVHRR images. The drifter programme is undertaken together with Canada Center of Inland Waters and Finnish Institute of Marine Research.

Sea ice

2.6 Sea ice mapping as well as sea surface temperature ,using AVHRR images as input are operational at SMHI. The products are used for icebreaking activities and shipping. Work is in progress to transmit prepared images to the icebreakers in the Baltic, using the Nordic Mobile Telephone net. Considerable efforts are put on the preparations for the ERS-1 satellite, with emphasize on sea ice applications of the synthetic aperture radar (SAR). During 1988, an international field programme was undertaken involving the Canada Center of Remote Sensing airborne SAR. A dedicated ground observation programme made it possible to study the SAR response on various sea ice features and internal physical structure. The developments from this field experiment are used to obtain an optimal geophysical calibration and validation experiment for the ERS-1 which will take place during January to March 1992 along with a demonstration experiment. Tests of ERS-1 SAR data will also take place in August to November 1991 during the high Arctic interdisciplinary expedition with the Swedish icebreaker Oden.

Data collection

2.7 Hydrological data collection from one mountain station has continued using the ARGOS system. Two drifters using the ARGOS positioning facilities has been used during 1990 and a further three will be used for research purposes during 1991. One drifter is planned to be in a stand-by mode for accidental oil spill tracking.

PART IV System for satellite applications in current operational use

Description of PROSAT.

4. The system is briefly described in PART I. A more complete description can be found in Karlsson and Liljas,1990.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. The PROSAT system will continue to be the basic processing system for satellite applications in meteorology, oceanography and hydrology for the following years. The system will be continuously adapted to a new computer environment.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6.1 A verification system for the multispectral classification scheme has been developed. The operational verification starts in 1991.

6.2 The subjective verification of the output has been reported in Karlsson and Liljas,1990.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

7.1 Staff

Bertil Hakansson	Oceanographic applications and ARGOS buoys
Karl-Göran Karlsson	Meteorological applications
Erik Liljas	Meteorological applications
Mats Moberg	Hydrological applications
Gunnar Pettersson	System hardware and software
Sten Orrhagen	System hardware and software
Jan Svensson	TOVS retrievals
Thomas Thompson	ERS-1 preparations, sea ice remote sensing

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SWITZERLAND

Swiss Meteorological Institute

PART I Summary of the major highlights of research applications and operational changes

1. In 1990, no major changes in operations and no new research have taken place at the Swiss Meteorological Institute (SMI). The reception of METEOSAT data through the PDUS/SDUS at Locarno as well as through the SDUS at Geneva and regular transmission of PDUS-derived and SDUS images to the regional forecasting offices has been continued.

PART II Major research and development in the applications of satellite data, derived products and services

2. No major activity.

PART III A description of techniques development and applications of satellite data, derived products and services

3. No major activity.

PART IV System for satellite applications in current operational use

4.1 The operational schemes and systems have continued their service throughout 1990. PDUS-derived image of Meteosat are transmitted at hourly intervals to the regional forecasting offices. The images of all three radiometer channels are presented in polar stereographic projection. The area covered corresponds approximately to format B of the PDUS transmission. The PDUS-derived images are converted to SDUS frames for dissemination, i.e. the WEFAX transmission standard is used.

4.2 In order to take full advantage of the higher resolution of the visible channel, a second visible picture with the coverage restricted to the area around the Alps is transmitted as well. The visible pictures are normalized for sun angle with the procedure described in Binder P.,1989: A Normalization Procedure for METEOSAT Visible Channel Data, J. Atmos. Oceanic Technol., 6 ,67-75. It is implemented through table look-ups; the tables are re-calculated every night.

4.3 The polar stereographic projection of all three channels and the brightness normalization of the visible pictures in real time considerably improved the operational use of the METEOSAT images, especially when viewed in action replay on the SARA display terminals. The SARA display terminals at the regional forecasting offices allow for action replay speeds of up to 25 frames, very useful when viewing cloud scenes over mountain ranges, as well as for interactive bit-slice colouring and zooming of the images. B/W hard copies are available on laser facsimile devices.

4.4 The PDUS-derived imagery on the display terminals and laser facsimile devices is complemented and backed-up by SDUS frames, which are distributed over the same data lines.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. It is planned to acquire a new PDUS and to distribute satellite imagery, together with the other meteorological products, via high speed WANs and LANs to a network of workstations in the regional forecasting offices.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6. No activities.

THAILAND

Meteorological Department

PART I Summary of the major highlights of research applications and operational changes

1.1 At present, the Meteorological Satellite Receiving Station receives signal from NOAA-10 and NOAA-11 which are NOAA polar orbiting satellites and GMS-4 which is the Japanese geostationary satellite. NOAA-10 and NOAA-11 provide AVHRR (Advanced Very High Resolution Radiometer) and TOVS (Tiros Operational Vertical Sounder) data. The station also receives S-VISSR (Stretched-Visible and Infrared Spin Scan Radiometer) from GMS-4.

1.2 In 1989, new equipment was installed at the Meteorological Satellite Receiving Station. There are several software application programmes which are:

- Sea surface temperature
- Tovs data application
- Typhoon tracking and forecasting
- Cloud tracking
- Satellite cloud wind
- Colour images.

1.3 Most of meteorological satellite images have used for daily weather forecasting, aviation and warning system. In addition, the Meteorological Department is conducting crop monitoring and flood monitoring.

USA

National Weather Service

PART I Summary of the major highlights of research applications and operational changes

Physical retrieval system (Fleming)

1.1 A physical retrieval system has been developed for retrieving vertical temperature and water vapor mixing ratio profiles from TOVS satellite radiance observations. The system has been implemented and used as the NESDIS operational retrieval system since September 20, 1988. The unique features of the system are that it: (1) determines the temperature/moisture profiles simultaneously as a single solution vector, (2) the retrieval operators are predetermined from mean temperature and moisture conditions representative of major air masses, and (3) radiance vectors from an a priori library of collocated radiosonde temperature/moisture profiles and radiance vectors are searched for those that are closest to a given observed radiance vector; the average of those radiance vectors chosen, along with the average of the corresponding temperature/moisture vectors, are used as the initial guess vectors in the retrieval.

Stratospheric constituents (Planet, Bowman)

1.2 A NOAA Technical Report - NESDIS 53 - "NOAA-9 Solar Backscatter Ultraviolet (SBUV/2) Instrument and Derived Ozone Data: A Status Report Based on a Review on January 29, 1990" was published. This report contains the materials presented at, and constitutes an official record of, the review. Fourteen NOAA and NASA scientists contributed to the review with topics covering the operational status of the instrument and the evaluation of data.

1.3 Many improvements and corrections to the software that processes the SBUV/2 satellite data into total ozone values have been initiated. This has been reflected in our comparison with ground truth (Dobson spectrophotometer observations) which has shown a significant improvement over the initial processing of the SBUV/2 data. NESDIS currently has a data set for NOAA-9 from March 1985 to October 1990 and for NOAA-11 from January 1989 to August 1990. The data are being evaluated and initial estimates of trends are being developed.

1.4 A new method of calculating lower stratospheric ozone values based on measurements with the operational infrared sounder has been implemented into the NESDIS operational processing. This new physical retrieval method is superior to the old regression method, especially in detecting the Antarctic ozone hole and extending coverage to a larger portion of the globe.

Sea surface temperatures (Sapper)

1.5 Observations of sea surface temperature at 8-kilometer resolution continued to be produced from NOAA-11 infrared data during 1990 and transmitted to the National Meteorological Center of the National Weather Service, the Navy Fleet Numerical Oceanography Center, and the World Meteorological Organization for use in oceanographic and meteorologic models and products. These observations are used to produce a 100-kilometer global resolution chart and 50-kilometer and 14-kilometer regional resolution charts.

1.6 Observations of sea surface temperature at 1.1-kilometer resolution at nadir will soon be produced operationally from NOAA-11 LAC and HRPT infrared data. These observations will allow for the production of sea surface temperature images. These images will be sent to Ocean Products Center for later distribution to regional coastal users through NOAA's CoastWatch programme.

Radiation budget (Sapper)

1.7 Global measurements of daytime and nighttime outgoing longwave flux and incoming available and absorbed solar radiation continue to be produced from NOAA-10/11 infrared data. Presently, there is testing being performed on the NOAA-K,L,M Radiation Budget Orbital Processing Programme complete with new algorithms and new derived parameters. Outgoing Longwave Radiation (OLR) fluxes from HIRS and the co-location of GAC targets with HIRS spots are among some of the new derived parameters and new algorithms.

Aerosol (Sapper)

1.8 Production of operational aerosol data continued in 1990. The following is a list of aerosol products currently being archived:

- Aerosol Weekly 100-Kilometer Analyzed Field File -a 1-degree resolution file containing specific information pertaining to global latitude and longitude intersections, i.e., optical thickness, gradients, number of observations used for analysis, etc.

- Aerosol Daily Summary Table - contains statistical information pertaining to aerosol observations in each (10 x 10) degree latitude/longitude box.

- Aerosol Monthly Mean Field File - a gridded file of optical thicknesses and other information. The optical thickness at each gridpoint is the average of optical thicknesses calculated for each week within the month at that gridpoint.

- Extreme Events Aerosol Observation File - this file contains 37 days of aerosol observations of optical thicknesses which are above a threshold of 0.2.

Future plans - There are future plans to implement the aerosol correction factor for sea surface temperatures. However, it is presently in the experimental stage of development.

Winds (Hughes, Lynch)

1.9 During 1990, experimental high-density winds were produced across the western North Atlantic during the hurricane season for the National Hurricane Center. Software was implemented to automatically generate cloud motion vectors from infrared imagery using a "CO_2 slicing methodology" for height assignments (this data set provided high quality and high volume vectors at/above 400mb and at/below 850mb). VAS gradient winds provided mid-tropospheric coverage for the subtropics poleward of 25N (this data set

provided high quality and high volume data for the mandatory levels of 400mb, 500mb, and 700mb). In addition, automatically tracked water vapor motions augmented data coverage above 400mb.

1.10 During 1991, the experimental high-density data set will be evaluated for possible assimilation in numerical models, and a subset will be identified for operational implementation in 1992 including exchange on the GTS and permanent archival. Also during 1991, "CO2 autowinds" will be implemented operationally to provide low density cloud motion vectors for the GOES full disc. By early 1992, autowinds using a water vapor height assignment schema will be produced from METEOSAT-4, expected to be on station near 50W (M4 winds will be used to supplement coverage between M5 and GOES-7). (Lynch)

1.11 A one-satellite wind operation (GOES-7) has continued since January 1989. The size of the target area for low-level cloud motion determination was increased to 32 x 32 pixels in February 1990 with a measurable improvement in wind quality and negligible processing cost. As an outgrowth of continued discussions among satellite wind providers, a First International Winds Workshop has been scheduled for September 1991 in Washington, D.C. (G. Hughes)

Volcanic Ash (Matson)

1.12 During 1989, a Volcano Hazards Alert Programme was implemented by NOAA and the FAA to detect and track volcanic ash to assist in commercial and general aviation avoidance. Using visible and infrared imagery from GOES and POES satellites, an analysis of the vertical and horizontal extent of volcanic ash is provided as frequently as every 2 hours (the analysis is used in SIGMETS, trajectory forecasts, and other aviation products).

1.13 Techniques to track semi-transparent volcanic aerosols are under evaluation. Multispectral data from the TIROS-N series satellites offer promise for tracking silicate material. The Total Ozone Mapping Sensor (TOMS) aboard NASA's NIMBUS-7 has been shown to be able to detect high concentrations of sulfur dioxide.

Images (Shellman)

1.14 Operational global and regional image products are produced in near real-time. The digital products are in the form of polar stereographic, Mercator, Lambert conformal, plate carree, and unmapped projections. A weekly global vegetation index is also derived. These products are produced from imagery recorded by NOAA's polar and geostationary orbiting spacecraft. Selected sectors of the mapped products are provided to national and international users via land and satellite communications systems.

1.15 Through the Shared Processing Programme, we receive, reformat, and distribute to the users the Air Force Global Weather Central/Defense Meteorological Satellite Programme's Satellite Global database and the Automated Cloud Analysis products.

Tropical Cyclone Research (Zehr)

1.16 Ongoing tropical cyclone research involves extensive analysis of large observational data sets in order to improve our understanding of hurricanes and typhoons. Three-hourly digital satellite data from the

Geostationary Meteorological Satellite (GMS), located at 140°E longitude, are being analyzed with respect to nearly 100 tropical cyclones in the West Pacific. One of the drawbacks of past tropical cyclone studies based on satellite observations has been the lack of "ground truth" data to verify the satellite diagnosis. U.S. Air Force reconnaissance flight data, available at Colorado State University from Dr. William M. Gray's research, are being used for this purpose. The aircraft data provide wind and pressure observations which measure the tropical cyclone's intensity and wind pattern. The intensity and extent of the deep convective clouds, which provide the energy to drive the tropical storm circulation, are calculated using the infrared data from GMS. In addition, objective analysis of operational data (radiosonde, aircraft, and satellite cloud drift winds) are used to reveal synoptic-scale features. Similar data, available for real-time analysis, are used to study tropical weather systems in Africa, the Atlantic-Caribbean, and the eastern Pacific.

1.17 Results have included important findings concerning the diurnal variation of heavy rainfall and cloud distributions as inferred from infrared temperature data. Objective satellite estimates of tropical cyclone intensity and size have been improved. New techniques to forecast tropical cyclogenesis are being developed.

PART II Major research and development in the applications of satellite data, derived products and services

DMSP satellite temperature profiles (Taylor and Pichel)

2.1 Work continued on the development of a physical retrieval technique to replace the statistical regression method used in the current Defense Meteorological Satellite Programme (DMSP) operational processing. In preparation for this transition, limb coefficients to correct all views to nadir received favorable evaluation and will be incorporated into the system in 1991. In addition, calibration problems causing errors of 2-3 K in the Special Sensor Microwave/Imager (SSM/I) database for the past 18 months were identified. A final validation of the NESDIS SSM/I data against the Navy SSM/I products will occur in March 1991. Extensive work has been done with the SSM/I data for use in the areas of surface type identification and surface emissivity measurements. Work continued in the areas of standardized quality control, to match TOVS procedures, and dynamic calibration procedures.

2.2 Preparations continued for the processing of data from the SSM/T-2 Moisture Profiler to be launched in the 1991-92 time frame. The DMSP Sounding System will then include 19 microwave channels from the SSM/T, SSM/I, and SSM/T-2.

2.3 Environmental products from the DMSP SSM/I are being generated to test algorithms, gain experience with microwave product production, and allow the National Meteorological Center and the Navy/NOAA Joint Ice Center to assess the utility of microwave products. Products currently being tested are precipitation rate over ocean and land, wind speed and total precipitable water over ocean, sea ice, and snow cover.

NOAA K, L, M Polar temperature/moisture profiles (Gray or Drahos)

2.4 Work on implementation of System '90 or RTOVS (Revised TOVS) operational sounding system is continuing. The RTOVS system will continue to produce the current sounding suite of products and retain the current TOVS product resolution (grid spacing) and minimum variance/simultaneous physical retrieval science. Science upgrades include a radiance classification first guess technique, utilization of the AVHRR/GAC for improved cloud clearing, and enhanced quality control for the system and products (based upon forecast comparison). The system is to be implemented in the late spring of 1992 and there should be some slight product improvement, but no format or data volume impact upon the user. Work on the science/system definition for System '92 or ATOVS (Advanced TOVS) has also continued. This system is to be installed when NOAA-K is launched (after the beginning of 1994). The product resolution (grid spacing) is defined to be that of the AMSU-A, however, this will be obtained by collocating AMSU to the HIRS locations. Improvements include use of very high speed computers to incorporate better physics, more accurate products because of the AMSU instrument, and utilization of the NMC 6-hour forecast for quality control and a choice for the retrieval first guess based upon either the radiance classification or NMC-6 hour forecast, whichever is better. Distribution and archive of the NOAA-K/AMSU products will require major revision to the distribution systems. Planning for these changes in addition to new calibration procedures are under way.

TIROS Operational Vertical Sounder (TOVS) (Chalfant)

2.5 Currently, TOVS operational sounding products are being derived from data acquired from NOAA-10 and -11 polar orbiting satellites. These satellites are scheduled to be replaced by NOAA-D and NOAA-I in May 1991 and December 1991 respectively. Several science improvements have been implemented into the TOVS operation over the last year which affect the reliability and accuracy of the sounding (or related) products. These included the implementation of a physical retrieval technique for the derivation of total ozone from the HIRS/2 instrument, procedures to improve cloudy sounding accuracy, and procedures to improve the quality and meteorological representation of the radiosonde/retrieval data used for the tuning of the TOVS sounding products. In addition, interactive image/graphics systems have been implemented for throughput and quality monitoring of the sounding products and are used for the evaluation of proposed science improvements prior to their implementation in the operation.

2.6 Work is continuing in the development of improved quality control procedures using a 6-hour forecast and use of radiometric data to improve the first guess used for the retrieval process. Also, techniques are being investigated to improve cloud clearing to make a more accurate determination between partly cloudy and cloudy soundings.

GOES-I/M soundings (Gray)

2.7 Development and implementation activities in support of an operational GOES-I/M sounding system are in progress. The initial "Day-1" sounding products to be produced from GOES-I include vertical temperature and moisture profiles for input to the National Meteorological Center's (NMC) regional numerical forecast models, derived product images of total precipitable water and lifted index for use by the National Severe Storms Forecast Center (NSSFC), and cloud height and amount information above 12,000

feet to supplement observations from the National Weather Service's Automated Surface Observing System (ASOS) planned for operation beginning in the mid-1990s. In addition, the vertical temperature and moisture profiles are to be used along with other information in producing deep layer mean wind products, for use by the National Hurricane Center (NHC). The Initial Operational Capability (IOC) version of the sounding system was successfully demonstrated in 1990, and is ready to produce the Day-1 products (with the exception of the ASOS cloud height and amount information). Plans call for the completion of the Final Operational Capability (FOC) by mid-1992, which will be capable of generating all Day-1 products, as well as providing additional functions such as product monitoring, quality control and archive. The launch of GOES-I is now scheduled for the Fall of 1992.

Improved VAS retrievals (Hillger)

2.8 Software for optimal grouping of GOES VAS radiances for averaging prior to temperature retrievals has been developed. That software has been tested and has been exported to ERL's Forecast Systems Laboratory for evaluation. This "clustering" technique uses the noise levels of the VAS channels as the grouping criteria for producing homogeneous soundings. Retrievals produced from conventional data groupings and from clustered radiances will be compared on a mesoscale region, including eastern Colorado. An explanation of this technique appeared in the December 1990 issue of the Journal of Applied Meteorology.

Noise-level analysis of GOES-VAS (Hillger)

2.9 An extensive analysis of special 10-spin-per-channel VAS data was undertaken to intercompare various techniques for determining the noise levels of operational VAS measurements. The noise level analyses provide an independent assessment of the GOES-VAS instruments performance, and the methodology is transferable for noise analysis of other types of satellite data, either geostationary or polar orbiting. Results of this intercomparison will appear in an upcoming NOAA Technical Report (No. 56). The structure-analysis method used in the report is presently being implemented on the VAS Data Utilization Center (VDUC) terminal at the Co-operative Institute for Research in the Atmosphere (CIRA). Results have been used to help devise a new VAS spin budget for operational purposes.

International Satellite Cloud Climatology Project (ISCCP) (Jacobowitz)

2.10 More than seven years of data of the twelve year collection period (July 1983 - June 1995) have been accumulated for this project. NOAA/NESDIS contributes Level B2 data for both operational polar orbiters (NOAA-10 and NOAA-11), as well as correlative data, including NMC surface observations, TOVS sounding product, GOES orbit and attitude data, snow cover, and sea ice analyses. The first five years of Stage B3 data (through June 1988) have been processed and are archived at the ISCCP Central Archive (which is in NESDIS' Satellite Data Services Division).

2.11 ISCCP's Global Processing Center (NASA/GISS) has recently generated the Stage C2 data, which are monthly averages and summary statistics of the cloud data Stage C1 from the global network of satellites (both polar orbiting and geostationary). The C2 data include three-hourly reports at 250 km resolution of the frequency of cloud occurrence and an error estimate, the

spatial mean and standard deviations of cloudy and clear sky radiances (0.6 and 11mm), the surface temperature and solar reflectance, surface type and topography, atmospheric temperature and humidity profiles, and ozone column abundance. These data are currently available from July 1983 through December 1986.

NOAA Satellite observations of aerosol optical thickness over oceans (Stowe, McClain)

2.12 The derivation of aerosol optical thickness over the oceans from NOAA/AVHRR (Advanced Very High Resolution Radiometer) data is now operational at NOAA/NESDIS. The individual 8 km resolution observations and the 100 km gridded analysis fields are archived in chart form and on magnetic tape at the NOAA/National Climate Data Center in Asheville, NC 28801.

2.13 The data are useful for monitoring the occurrence and following the transport of aerosol particles generated by dust storms, air pollution episodes, agricultural and forest fires, and volcanic eruptions. Recently, the derived optical depth values have been shown to be useful for correcting AVHRR derived sea surface temperatures off the West Coast of Africa in the presence of Saharan Dust.

Remote sensing of cloud parameters with NOAA satellite data (Stowe)

2.14 NOAA/NESDIS has been generating cloud top pressure and effective cloud amount (emissivity) as a by-product of their operational atmospheric temperature/moisture retrieval process. Recently, intercomparisons with other satellite derived cloud parameters indicate the cloud top pressures and amounts are systematically too large. An improved cloud retrieval system is under development at NESDIS which uses adjacent channels in the 15 micron carbon dioxide absorption bands of the HIRS (High-resolution Infrared Radiation Sounder). It should be implemented in the next year.

2.15 NESDIS has also been developing a multi-spectral cloud parameter retrieval programme with AVHRR (Advanced Very High Resolution Radiometer) data. Termed CLAVR (Clouds from AVHRR), it uses all five channels in a sequence of decision-tree threshold tests to classify 8 km resolution (2x2 field-of-view arrays) observations as clear, mixed (partly cloudy), and cloudy. This algorithm is being implemented into the operational data stream for real-time experimental production and evaluation of total cloud amount over the globe. In the next few years, the CLAVR algorithm will be enhanced and merged with cloud parameters derived from HIRS and the AMSU (Advanced Microwave Sounding Unit) sensors to provide real-time, global estimates of cloud amount, cloud type, cloud top altitude, temperature, and pressure, liquid and ice water content, and optical thickness and emissivity, at half degree (50 km) resolution, in up to five layers of the atmosphere.

Satellite Earth radiation budget studies (Jacobowitz)

2.16 The Earth radiation budget is currently derived from the Advanced Very High Resolution Radiometer (AVHRR) narrowband channels on the NOAA polar-orbiting satellites utilizing models to estimate the broadband albedos and fluxes and to account for the anisotropy and the diurnal variation of the reflected radiation. Improvements are being made to the models that estimate the broadband albedo from the spectral albedos in the visible and near IR channels, which should reduce the errors considerably. The models will now be scene dependent. Similarly, regional models are being developed, which will reduce the error in estimates of the outgoing longwave (OLR) radiation.

2.17 An algorithm has been developed and tested for deriving the OLR from four channels of the High Resolution Infrared Radiation Sounder (HIRS) and will be generated routinely, in addition to the OLR derived from the AVHRR. A new data system for deriving the retrievals from AVHRR and HIRS data is being tested and is expected to become the operational system very soon.

Mesoscale convective cloud climatologies (Weaver)

2.18 A project to construct high resolution GOES visible and infrared cloud climatologies over the United States has been underway for several years. Such climatologies provide a detailed look at the effect of local terrain variations on the convective cycle; especially over the Rocky Mountains, Gulf of Mexico coastal areas, and the State of Florida. They are excellent for detecting preferred regions for cloud formation under differing synoptic scale flow regimes. Findings have been incorporated into expert system forecast applications and have also been used to provide input to various regional convective studies. The project continues and has recently been expanded to include selected composites over northern sections of South America and Brazil.

Polar low research (Lubich)

2.19 Multispectral data from GOES and AVHRR imagery from TIROS are being combined with DMSP SSM/I data to conduct research on polar lows. The satellite data is being used in conjunction with conventional data to study the detailed life cycle of several polar low events occurring around Greenland. Analysis has shown that GOES visible imagery may be used to track cloud motions at high latitudes, especially if those data are animated in a cloud system relative frame versus the conventional earth relative framework normally used for animation. For one case, where a polar low developed near the Davis Straits, an upper level disturbance could be tracked in water vapor data for over 24 hours prior to the polar lows development.

Weather forecasting - Severe local storms (Anderson)

2.20 Research was conducted to identify thunderstorm cloud top changes in GOES rapid scan imagery which can be used to issue severe weather warnings when this data becomes generally available in real time to field forecasters. Five minute interval visible, IR and water vapor imagery was analyzed for the Plainfield, Illinois tornado of August 1990. Also analyzed were radar observations and five channels of HRPT data from a NOAA polar satellite overpass of the storm. An aerial storm damage survey conducted immediately after the storm was an integral part of this study, since it established the precise location and strength of the tornado during its life history.

2.21 Results show that animated "storm relative" motion sequences are most useful in detecting those cloud top changes that relate to the initiation of severe surface weather. Cloud changes observed in the animation were relative to convective storm motion determined by the movement of associated radar echoes.

2.22 This is an ongoing project with Dr. T. Fujita of the University of Chicago.

Severe and tornadic storms (Purdom)

2.23 GOES rapid scan imagery and TIROS AVHRR data are being used in conjunction with conventional surface, upper air, and radar data to study severe and tornadic storm development and evolution. Analysis of rapid scan imagery for tornadic storms, in a storm relative animation mode, consistently shows strong veering between the cumulus and cirrus level cloud motions. For several super cell tornadic storms, cool low level outflow produced by the storm early in its life cycle seems to play an important role in the tornadic storms evolution. Other storms become tornadic after interacting with the low level outflow from an earlier storm. Cloud top characteristics associated with severe storms are currently under intense investigation using GOES visible and infrared imagery and all channels of TIROS AVHRR imagery.

UN/ESCAP Satellite Crop Monitoring Project for South/South East Asia (Achutuni)

2.24 The Satellite Crop Monitoring Project uses NOAA AVHRR data in combination with rainfall analysis and statistical climate crop yield models to assess crop conditions throughout the growing season in developing countries in South and Southeast Asia. The individual country needs and requirements are factored into the design of an appropriate programme. The goal is to provide real-time input to Climate and Crop Condition Bulletins for use by key decision makers in concerned Government agencies. The NOAA/NESDIS Office of Research and Applications (ORA) is actively involved in both the technical development and its transfer. The current Phase II of the Project, funded by the U.S. Agency for International Development and the United Nations Development Programme and administered through the Economic and Social Commission for Asia and the Pacific (ESCAP), is drawing to a close. A five-week workshop was held in Bangkok, Thailand, during June and July of 1990 for government agency employees from Indonesia, Malaysia, the Philippines, and Thailand. Follow-up in-country visits were conducted by ORA scientists to ensure that the software for providing satellite-derived vegetation indexes was being used in operational crop assessment bulletins. These were followed by a Regional Evaluation Seminar in November, 1990 for the trainees and high-level agency officials. Plans for Phase III include drought/flood monitoring, flood forecasting, cyclone/typhoon warning, and teleconnections analysis (El Niño Southern Oscillation) in addition to continuation of vegetation and crop monitoring and sea-surface temperature anomalies. Training activities (in-country, regional, and U.S.) will be expanded to an additional ten countries: Pakistan, India, Bangladesh, Nepal, Sri Lanka, Laos, Cambodia, Vietnam, Mongolia, and the People's Republic of China.

MICVEGI: A personal computer data base software package for creating and displaying normalized difference vegetation index time series data (Phillips)

2.25 The MICVEGI software system, designed to run on an IBM or IBM-compatible XT or AT microcomputer, provides a comprehensive series of integrated functions allowing the user to create, maintain, and analyze satellite Normalized Difference Vegetation Index (NDVI) time series data. MICVEGI contains functions to identify data locations, geographically define irregular polygons, and specify up to five different NDVI data formats (1-, 2-, 3-, 4-, and 5-week time periods). Once the user has established the data framework, the MICVEGI programme extracts scaled NDVI data from satellite files and stores an averaged scaled NDVI value for each time period and polygon.

The user can then enhance the resulting NDVI profiles with the 4253H "Twice" smoothing method. MICVEGI offers full listing and plotting display on a VGA graphics monitor and an Epson graphics printer with the user specifying the time period (a portion of the year or the entire year) and the years of data (up to five different years possible) to be displayed. The MICVEGI software can also create space-delimited output files of user-specified polygons for downloading to spreadsheet and statistical analysis software. This software was jointly developed by the Climate Applications Branch (NOAA/NESDIS/ORA/SAL) and the Co-operative Institute for Applied Meteorology (University of Missouri-Columbia) for use in the production of crop condition assessment bulletins.

Role of OLR data as a proxy for the 25mm significant rainfall line in the African Sahel (Starks, Achutuni)

2.26 As part of the Famine Early Warning System (FEWS), NOAA AVHRR Outgoing Longwave Radiation (OLR) data are used to define the dekadal (10 day) latitudinal position of the 25mm Significant Rainfall Line (SRL) in the Sahel region of Africa. OLR data for the Sahel are converted from the polar stereographic projection to a Platte Caree projection using the subroutine IJTOLL provided by the NOAA Satellite Data and Services Division. The lowest pixel value for a given location in a given dekade is identified and retained in a separate computer file. OLR and corresponding precipitation data are then gridded and smoothed with the graphics package SURFER. The latitude of the 25mm isohyet is determined for each one degree of longitude (18°W to 23°E). OLR values at the isohyet latitude are then determined and tabulated. Descriptive statistical analysis revealed that the average OLR value, corresponding to the 25mm SRL, is approximately 160 Wm-2 with a standard deviation of 20 Wm-2. Because a statistical mean can be affected by extreme values, the use of the OLR mean value as a proxy for the SRL was suspect. Thus, a nonparametric test was used to determine if the mean OLR value could be used to indicate the SRL position. A Kolmogorov-Smirnov one-tailed two-sample test revealed that the latitudinal position of the 160 Wm-2 isoline is no different than that of the latitudinal position of the 25mm SRL. Therefore, the dekadal 160 Wm-2 value can be used as a proxy for the dekadal 25mm SRL.

2.27 Statistical analysis of the SRL and OLR latitude data suggest that both variables possess a near-normal distribution. The results of an analysis of variance (one-way) run on the data indicate there is no difference between the variable means. This provides additional support for the use of the 160 Wm^{-2} OLR latitudinal position as a surrogate for the 25mm SRL position.

Monitoring drought from space (Kogan)

2.28 An algorithm was designed to use the NOAA/NESDIS Global Vegetation Index (GVI) for drought monitoring on continental and regional scales. GVI is NOAA operational product issued weekly in real-time for each 16 km by 16 km grid between 75¡N and 55¡S. The developed algorithm included modification of GVI into the Vegetation Condition Index (VCI) through noise reduction and enhancement of ecological and weather signals. This index proved to be most useful for monitoring weather impacts and condition of vegetation, and through them drought. A pilot test, was performed on the 1988-1990 satellite data for the entire United States. This test showed that the pattern of drought identified by the Vegetation Condition Index matched very well with the pattern outlined from ground observations of precipitation and agricultural

crop yield. The VCI showed an excellent ability to detect drought and to measure the time of its onset, intensity, duration, dynamics, and impacts on vegetation. The VCI provides appropriate drought information not only for the cases with well defined, prolonged, widespread, and very strong droughts (1988) but also for very localized, short-term, and not well-defined droughts (1989, 1990). A verification of the algorithm is also in progress for sub-Sahara Africa droughts. The current efforts are intended to develop operational algorithm for drought monitoring on the global scale.

Precipitation (Scofield)

2.29 Water vapor imagery (6.7 @m) frequently shows boundaries of relatively "deep" moisture that extend northward from the Inter-tropical Convergence Zone (ITCZ), Mexico, or the Gulf of Mexico. Sometimes, these boundaries take on a plume-like appearance. Descriptively, we refer to these as the "Mexican or ITCZ Connection." Such boundaries seem to be related to high values of theta-e air, at low and mid-levels. They emanate from the tropics and subtropics and extend to the mid-latitudes. Southwest U.S. monsoonal flow enhances the appearance of the moisture plume. A strong connection appears to exist between this plume, high theta-e values at low levels, and Mesoscale Convective Systems that produce flash floods in the Rockies and regions to the east.

2.30 It appears that the "Mexican Connection" type of theta-e pattern also occurs in other parts of the world: (1) over the southern China to Taiwan area during the Mei Yu season (the "Southern China/Taiwan Connection"), and (2) over Europe in the form of an "African Connection" (the Spanish Plume).

Turbulence (Ellrod)

2.31 An objective index for determining the risk of high altitude clear air turbulence (CAT) has been developed and is now an operational tool of the National Meteorological Center (NMC) in Washington, DC, as well as at other Government or military forecast centers. The turbulence index (TI) is based on vertical wind shear and deformation, two properties that are highly correlated to CAT. Numerical model forecast winds aloft that are used to derive the TI employ satellite-observed cloud motion and radiometric data from Tiros Operational Vertical Sounders (TOVS) as input for the initial analysis. Verification of TI over the United States indicates that 80% of significant CAT events were correctly forecast 24 hours in advance. About 15-20% of the forecast events were "false alarms." A climatological study is underway that uses average TI values to determine regions of the Northern Hemisphere that are especially prone to CAT.

Fog detection (Ellrod)

2.32 A technique that determines the extent of fog and stratus during the nighttime hours has been developed using two infrared (IR) channels from GOES-VAS. Regions of low stratus appear slightly cooler (3-6°C) in the mid-wavelength IR (3.9@m) channel than in the longwave IR (11.2@m) channel. An image differencing process enhances the thermal contrast, providing information on the areal coverage of fog or stratus to aviation forecasters.

2.33 Data on fog thickness, derived from aircraft reports, was collected for about 60 cases of dense fog. The fog thickness was found to be directly related to the digital brightness difference for the two IR channels. Based on this relationship, an image enhancement scheme was developed that estimates the fog depth, an important parameter for forecasting the time of clearing.

Interactive retrieval system (Fleming & Goldberg)

2.34 An interactive retrieval system is one in which the data assimilation and forecast functions of a NWP system are linked directly with the satellite temperature/moisture retrieval system. In particular, the six-hour forecast is used as the initial guess in the retrieval system, the retrieved profiles are assimilated by the NWP analysis system, a new six-hour forecast is made, which in turn is used as the initial guess of the retrieval system, and a closed cycle is continued in this manner.

2.35 A major feature of the current interactive system research is to tailor the retrieval system to the specific needs of the NWP model. This means that: (1) mean virtual temperatures and mean specific humidities over the sigma layers of the model are retrieved directly, (2) the retrieval operator is based on the forecast at each satellite location to minimize the nonlinear effects of the operator, and 3) the retrieval surface pressure is variable and dictated by the forecast surface pressure.

Expert system forecast applications (Weaver, Phillips)

2.36 Developmental work on various expert system applications for forecasting severe convective weather continues. The combined system addresses convective weather over both the High Plains and the Central Plains of the United States. The systems have been rigorously tested through formalized experiments at the Environmental Research Laboratory, and through real-time usage in field offices of the National Weather Service.

2.37 Upgrades currently under development focus primarily on the incorporation of additional satellite data, in both objective and subjective form. The systems are scheduled for further testing during the summer of 1991.

PART III A description of techniques development and applications of satellite data, derived products and services

Multidiscipline Interactive Display and Analysis System (Matson)

3.1 The Multidiscipline Interactive Display and Analysis system (MIDAS) was installed in 1990 to support GOES-I product development and production. Its major components are a IBM 4381 Model P24 central processing unit, an IBM 3745 communications controller, two IBM 3990 disk controllers, 20 GB of IBM DASD, and six Wide Word Workstations provided by the University of Wisconsin. The applications software is also provided by the University of Wisconsin. MIDAS will be used in conjunction with the operational VAS Data Utilization Center (VDUC) to support GOES-7 and GOES-I operations (e.g., winds, soundings, precipitation).

Interactive Digital Image Display and Analysis System (Matson)

3.2 The Interactive Digital Image Display and Analysis System (IDIDAS) is a 386 PC-based system designed for the display and analysis of NOAA POES data. It combines menu-driven, interactive commercially-available hardware components. The hardware consists of an 80386 PC, a high resolution graphics card, a high resolution color monitor, a standard communications capability

such as a modem or Ethernet, and standard output devices such as a laser printer or high resolution plotter. The software is written in "C" and includes extensive documentation and NESDIS support tc users.

PART IV System for satellite applications in current operational use

GOES I-M Status and Outlook (McGunigal)

4.1 The GOES I spacecraft is projected for launch in the fall of 1992. The spacecraft "bus" is undergoing qualification testing at Space Systems/Loral with the prototype imager and sounder instruments installed. This work will be completed in June 1991, and the spacecraft will then be put into storage until the flight instruments are delivered.

4.2 The imager and sounder instrument development activity at ITT remains on the critical path to launch. The assembly of both instruments is complete and they are currently being tested to establish detailed performance characteristics.

4.3 The GOES I-M ground system is completed and will be ready to support system checkout and operations when GOES I is launched. The spacecraft will be launched by an Atlas/Centaur vehicle.

GOES Data Collection System (DCS) (Staton)

4.4 NOAA installed and made operational new ground processing equipment for the GOES DCS. The DCS Automated Processing System (DAPS) became operational in December 1989, and provided much needed expansion capability and also provided dissemination functions. DAPS allows NOAA to expand, as required, to process all 200 domestic and all 33 international DCS channels. DAPS also supports the new dissemination function of broadcasting all DCS data on a single Ku-band channel, via a commercial communications satellite. The footprint of this broadcast is the 48 contiguous states, southern Canada, and northern Mexico. Through this service, a user with a small (1.2m to 2.4m) antenna, interface card, and a PC can receive data from upwards of 3,000 different platforms. Since all platform data are broadcast through this service, agencies can easily share data.

GOES WEFAX (Staton)

4.5 NOAA began the implementation of a computer-readable code on its WEFAX image products. The code is in the format proposed by the Coordination Group on Meteorological Satellites. With this code, computers can determine the product type and selectively process the data.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

NOAA K,L,M (Durham)

5.1 The NOAA K,L,M series of satellites represents the first significant upgrade in the basic instrument complement on the National Oceanic and Atmospheric Administration (NOAA) series of sun-synchronous, polar orbiting spacecraft since the launch of TIROS-N in October 1978. The first launch in this new series is planned for 1994.

5.2 Planned changes include on-board calibration and small increases in the number of channels and data resolution in the imager. Smaller but still important improvements are planned in several of the other instruments. A NASA developed ozone mapping instrument will be added for the first time. These upgraded and added instruments will improve present TIROS-N products and provide a basis for generation of a number of new products.

5.3 The processing software for NOAA K,L,M products is being developed and delivered in phases. The new Image Products System is complete. The new Radiation Budget System will be completed in 1991 and a new sounding system using improved algorithms and imager data for cloud clearing will be completed in 1992. Software for processing microwave sounding data will complete the package with delivery expected in 1993. Microwave sounding data will greatly increase accuracy of both temperature and water vapor profiles and increase horizontal resolution by an order of magnitude.

GOES-I-M (Hughes)

5.4 Development continues for systems to process the GOES-Variable (GVAR) data stream. Analyses are ongoing to estimate the effects of changes to initial specifications suggested by the LORAL Corporation (prime contractor.) Evaluation of the LORAL-supplied earth-location algorithms is continuing.

GOES Data Collection Platforms (Staton)

5.5 NOAA is participating with other U.S. Federal agencies to develop specifications and certifications for higher data rate Data Collection Platforms (DCP's). It is planned that development of both 300 bps and 1,200 bps DCP and associated demodulators will begin in 1991, and become operational in 1992. The NOAA DCS ground equipment is currently capable of interfacing with these higher data rate DCP's. The 300 bps DCP will operate in the normal 1.5KHz channel for the GOES DCS while the 1,200 bps DCP will require 3.0 Khz channel. No degration of the current 100 bps will occur. The higher data rate DCP's will provide NOAA two very valuable new functions. First, DCP's can transmit more data in the same time assignments; this is very beneficial to various programmes such as seismic monitoring and some ocean applications. Secondly, where message lengths are not increased, more DCP's may put onto the same channel, effectively increasing the channel capacity by a factor of three or allowing the same DCP to transmit their data more frequently.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

SSM/I Validation (Alishouse, Wilkerson)

6.1 The SSM/I was launched in June, 1987. As part of a Calibration/Validation effort, NESDIS scientists were involved with the validation of products of total precipitable water (TPW) over the ocean, cloud liquid water (CLW) over land and oceans and surface wind speed over the ocean.

6.2 For TPW SSM/I retrievals were compared with radiosonde observations (raobs) from small island stations. After initial biases and slope errors were removed, retrievals from the SSM/I and the raobs agree within 10%.

6.3 For CLW over land data from the NOAA profiler network in Colorado was used for July-September, 1987 and January-March, 1988. Results indicate that surface variability is larger than the cloud signal when the clouds are not precipitating. For CLW over the ocean, data from upward looking microwave radiometers placed on San Nicolas Island, CA (Project FIRE), and Kwajalein atoll were used. Results indicate that the SSM/I can reliably estimate CLW content from non-precipitating clouds over the ocean.

6.4 For wind speed validation, NOAA moored buoys are being used for the in-situ wind speed measurements. These will be compared with the SSM/I-derived wind speeds which will be evaluated in two ways. The first method involves direct comparison between SSM/I and in-situ measurements. The second type tests for self consistency of the SSM/I winds.

6.5 The wind data was categorized by climate area-tropics, low-latitude, mid-latitude, and polar. From data analyzed for 1987, the SSM/I winds show a bias of as much as 6 m/s too high and have scale biases that result in an over estimation of low wind speed and an under estimation of high wind speeds. The scatter remains within ± 2 m/s over the range 3 m/s to 25 m/s which is within accuracy specifications.

6.6 An evaluation of SSM/I data (without 85 GHZ channels) for detecting and depicting snow and ice cover was started in November 1990, using the operational Northern Hemisphere snow cover analysis (based on visible POES, GOES, and METEOSAT imagery) as ground truth. Systematic errors over desert areas, high plateaus, and coastal zones have been identified. Temporal inconsistencies will also be examined during the evaluation.

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USSR

State Committee for Hydrometeorology

PART I Summary of the major highlights of research applications and operational changes

1.1 In 1990, continuing use was made on a regular basis of information from the polar-orbiting satellites METEOR and OKEAN (USSR) and of NOAA (USA), and from the geostationary satellites GOES (USA), METEOSAT (ESA), and GMS (Japan) in meteorology and operational hydrology for the purpose of increasing the information content of synoptic and numerical forecasts of weather and ocean conditions.

1.2 The transition from the satellite system METEOR-2 to METEOR-3 has made it possible to improve the quality of meteorological parameters determined by remote means and, by so doing, to make more efficient use of satellite information. Regular launches of OKEAN satellites make it possible to make wider use of satellite hydrometeorological information (HMI).

1.3 As well as the operational use of satellite information, research has been conducted in the following main areas:

- The improvement of methods for deriving, from satellite data, digital hydrometeorological information of improved accuracy and resolution.

- Widening the range of parameters which are determined by remote means;

- Widening the use of satellite information in the analysis and forecasting of weather conditions.

PART II Major research and development in the application of satellite data, derived products and services

2.1 For its analysis and forecasting of weather conditions on a varying scale and within varying time-frames, and for monitoring the state of the oceans, the operational and scientific research departments of the Hydrometeorological Centre of the USSR make use of satellite information from the METEOR polar-orbiting meteorological satellites (the METEOR-2 and -3 series) and NOAA; from the geostationary satellites METEOSAT, GOES, and GMS; and from the oceanographic satellite OKEAN. Use is made of television, infra-red, and radar images of the cloud cover and underlying surface in analogue form (photomontages, individual photographs and images on the Automated Work Station Monitor "SYNOPTIK") and in digital form, as well as quantitative data gathered by remote sounding of surface and atmospheric meteorological parameters (SATEM summaries, digital ocean-surface temperature charts, etc.).

2.2 Photomontages and individual photographs from the NOAA satellite and from METEOR are used to determine the position of frontal boundaries and to forecast their movement across the territory of the USSR, and to refine daily forecasts for the central area of the European part of the Soviet Union using observations of the evolution of cloud formations. Global photomontages from METEOR satellites, photographs from METEOSAT, GOES, and GMS (using weather facsimile) are used to determine the position of frontal boundaries, ITCZ areas and the positions of tropical cyclones on that portion of the ocean not lit by the sun.

2.3 Satellite data (TV and infra-red photographs) are used to compile and refine predictions of hazardous phenomena at specific locations (e.g. heavy rain, snowfall and blizzards), to determine the extent of fog and of extensive areas of increased convection, and areas of gale-force winds (the Novaya Zemlya and Novorossijsk bora).

2.4 Charts giving the coordinates of forest and tundra fires, compiled using photographs from METEOR satellites, are used to pinpoint and predict areas of fire hazard using the technology of medium-term statistical weather forecasting.

2.5 Daily charts of the snow cover across the European part of the Soviet Union, compiled using photographs from METEOR satellites, are used in agro-meteorology for compiling and refining forecasts of snow-thaw; similar maps of the Northern hemisphere for a ten-day period are used in compiling forecasts of snow-thaw over the territory of the USSR.

2.6 Charts of ice conditions based on data from METEOR satellites are used by hydrologists to refine forecasts of ice-formation and ice-drift on large lakes and reservoirs in the European part of the Soviet Union.

2.7 In marine hydrology, satellite data, including photographs from polar-orbiting and geostationary satellites, and digital ocean surface temperature charts, are used to determine the position of thermal fronts, in assessing the ice conditions of inland waters or of seas contiguous with the USSR, in compiling charts of ice conditions in the Antarctic and in Arctic waters, in determining areas of increased wave activity, and in compiling navigational information for shipping.

2.8 Tables giving the amount of cloud cover at nodes on an established network are completing our store of statistical data for use in the climatological analysis of cloud cover.

2.9 Global data, obtained from atmospheric temperature and humidity soundings using the NOAA satellite (SATEM summaries), which reach the data base of the USSR Hydrometeorological Centre, are being incorporated into a system for objective analysis on a hemisphere basis.

2.10 Work is underway to increase the quantity of satellite data and expand the use thereof in weather analysis and forecasting. This work includes the development of methods for estimating the temperature of circumscribed areas of land using high-resolution infra-red measurements from the NOAA satellite, methods to assess radiation-budget components using data from the NOAA satellite and METEOR, and for calculating the speed of movement of large-scale cloud systems using images from METEOSAT (in weatherfax mode). Preliminary work is underway on the analysis of information from the Soviet

geostationary satellite GOMS to acquire quantitative data about the wind field, the temperature and the height of the upper cloud limit, and the temperature of water surfaces. Work is continuing on the development of technology and procedures for acquiring quantitative information on sea-level winds, on the nature and intensity of precipitation, and on the moisture content of the soil using measurements made using radiophysical apparatus on board the oceanographic satellite OKEAN.

PART III A description of techniques development in the applications of satellite data, derived products and services

3.1 Automated technology has been introduced for the processing of measurements made by TOVS apparatus on board the NOAA satellite to acquire, on a regional scale (i.e. covering the territory of the European part of the Soviet Union), quantitative data based on remote sounding of the vertical temperature and humidity profiles in the open atmosphere, and of cloud-layer parameters. The data provided by the soundings, (which are equal, in terms of accuracy, to the data provided by SATEM data disseminated along GTS channels), enter the Hydrometeorological Centre data base and are used in experimental attempts at incorporating them in a system of regional objective analysis.

3.2 Use has been continuing of operational technology for deriving data from atmospheric temperature soundings by processing measurements obtained using the ten-channel infra-red radiometer on board METEOR-2 and METEOR-3. The operational processing of this satellite information is conducted at satellite data reception points (Regional Data Reception and Processing Centres in Obninsk, Novosibirsk and Khabarovsk), and the results of this processing are transmitted in the form of SATEM summaries along communications channels to the data base of the Hydrometeorological Centre of the USSR. The accuracy of the data produced by temperature soundings is on average 1.5 times less accurate than soundings using the NOAA satellite.

3.3 Technology has been developed for processing satellite radiometric measurements of infra-red radiation in the 10.5 to 12.5 micron band, made using "KLIMAT" equipment on board METEOR-3, in order to produce digital ocean surface temperature charts and charts showing the heights of the upper-limits of cloud cover. The accuracy of ocean surface temperature assessment exceeds the accuracy of similar assessments based on data from METEOR-2. It is envisaged that this technology will process the satellite information at the satellite data reception points mentioned earlier, and also transmit the results of the soundings (in the form of digital charts) along communications channels to the Hydrometeorological Centre of the USSR.

3.4 Work is continuing on the testing and experimental use of computerised systems for producing digital charts showing the temperature of inland waters within the European part of the Soviet Union, using measurements obtained from TOVS and AVHRR equipment on board the NOAA satellite.

3.5 A computerised system has been developed for the high-speed interactive analysis, using personal computers, of digital images from TV, infra-red, and radar, with a view to determining the extent and distribution of drift-ice on ocean waters. The information on ice conditions acquired using this technology in various areas of water (for example, in the Western Arctic Sector), is transmitted via communications channels (including

electronic ones), to specific customers. For the period 1989-1990 there have been over 200 operational transmissions to customers of information on ice conditions.

3.6 There are a number of experimental procedures for analyzing satellite information (mostly radiophysical, and data from side-looking radar). They include the following:

- Methods for determining the speed of sea-level winds in areas of atmospheric convection using side-looking radar images, making it possible to determine their extent on the mesoscale;

- Methods for the identification of hail precipitation using side-looking radar images;

- Methods for assessing the degree of moisture penetration of the top layer of soil using side-looking radar images, making it possible to increase the degree of certainty of assessments of moisture penetration up to a depth of 10 cm. for areas of precipitation;

- A method for estimating the wind speed using the combined measurements of radar and ultra high-frequency radiometry.

PART IV Systems for satellite applications in current operational use

4.1 The technology for acquiring and using digital hydrometeorological information from METEOR (SATEM summaries, ocean surface temperature data), is of a distributed nature and provides for the reception of satellite data at Regional Data Reception and Processing Centres, the automatic processing of this data, and the formatting and transmission, along communications channels to Moscow, of final product reports (SATEM summaries, digital ocean surface temperature charts), for inclusion in the data base of the Hydrometeorological Centre of the USSR. In interpreting data from the METEOR satellites, use is made of estimates of weather parameters based on climatic averages.

4.2 Technologies for acquiring data from atmospheric temperature and humidity soundings (on a regional scale for the European part of the Soviet Union), and for producing digital ocean surface temperature charts from the NOAA satellite, have been developed at the Hydrometeorological Centre of the USSR. Additional information, in the form of the results of numerical short-term forecasting, is used in interpreting satellite data from NOAA. These technologies are completely automated.

4.3 The technology for plotting charts of ice conditions, and for the formatting and transmission of information on these ice conditions, is based on the interactive analysis of digital satellite images and has been introduced at the Hydrometeorological Centre of the USSR using personal computers.

4.4 Technologies, also of an interactive nature, for the analysis and interpretation of satellite radiophysical data are at the development and testing stage. A description of the meteorological satellite systems METEOR-2, METEOR-3, and OKEAN is contained in the report of the Eighteenth Conference of the CGMS (Geneva, 13-17 of February 1989), cf. (7.1.1), Annex VI.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 In plans for the further development of operational hydrometeorological satellite systems, provision is being made for the following:

- The launch and testing of the geostationary meteorological satellite GOMS;

- The further development and completion of the METEOR series of polar-orbiting satellites.

5.2 Descriptions of the equipment and the characteristics of these satellite systems are contained in 7.1.2.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6.1 In the acquisition of data from temperature and humidity soundings using METEOR and NOAA, provision is made for their validation by means of regular comparison with the most current available data from radiosondes and with the results of objective analysis. According to estimates for specific periods in 1989-1990, statistical estimates of the accuracy of SATEM data vary depending on the equipment used, while the standard deviation between satellite soundings and the data provided by objective analysis is 1.5 - 2.0 times greater than similar deviations for sounding data from the NOAA satellite. Additional statistical data on the accuracy of soundings using the METEOR satellites are given in 7.1.2 and 7.1.3. Work will be continued on the validation of global temperature soundings using the METEOR satellite and on assessments of its accuracy.

6.2 Validation of regional data from temperature and moisture soundings using the NOAA satellite was carried out using the same methods as used for SATEM data from the METEOR satellites. According to estimates for specific periods in 1990, the standard deviation (calculated as an average for ten layers between the surface and 100 Hpa) between data from temperature soundings and the results of objective analysis is 2.2-2.5°C for different periods. Additional information on this question is given in 7.1.3 and 7.1.4. The accumulation of statistical data on the accuracy of thermal soundings using the NOAA satellite will be continued.

6.3 Validation of data on satellite ocean surface temperature estimates, based on information from the METEOR-3 satellite, was carried out by means of comparisons with the results of objective analysis and with ship observations in the North-West Atlantic area for the period May-June 1990. The standard deviation is 1.5-1.7°C, with small systematic errors. Similar assessments are planned for the future.

PART VII Other items (references, publications and names of scientists in charge, etc.)

7.1 Further information on the development of satellite technologies and the application of satellite information in meteorology and operational hydrology can be found in the following publications:

1. The report of the 18th meeting of the CGMS, WMO, Geneva, 13-17 November 1989;

2. The report of the 19th meeting of CGMS, Tashkent, USSR, 10-14 December 1990;

3. A.B. Uspenski et al., Attempts to Develop Methods for Acquiring Satellite Hydometeorological Information. In the collection "On the 60th anniversary of the Centre for Hydrometeorological Forecasts" Leningrad, Gidrometeoizdat, 1989, pp. 207-237;

4. A.B. Uspenski et al., The Research Processing of TOVS Data in the Hydrometeorological Centre of the USSR. The Technical Proceedings of the 5th international TOVS study conference, Toulouse, 1990, pp. 384-405;

5. The use of radar in studying the Earth's surface from space. Investigation of the ocean surface and of ice cover using satellite side-looking radar. Edited by L.N. Mitnik, and S.V. Viktorov. Leningrad, Gidrometeoizdat, 1990, 200 pages;

6. M.V. Bukharov et al., The Analysis of the Spatial Structure of Areas of Rain Precipitation Using Side-looking Radar images. Studies of the Earth from space, 1990, No. 3, pp. 35-43;

7. M.V. Buhharov, T.H. Geokhlanyan, G.B. Bugaeva, Three-dimensional anisotropic medium-scale zones of moisture penetration of the soil layer and the synoptic conditions for their formation. Studies of the Earth from space, 1990, No. 6, pp. 29-36;

8. P.A. Nikitin et al., Attempts to use satellite radar imagery to assist in ice navigation." Produced by GosNITsIPR (the State Scientific Research Centre for the Study of Natural Resources), 1989, Issue 33, pp. 135-141.

7.2 Bibliographical information on the use of satellite data in practical work and in scientific research published in the USSR in 1990

TITLE: Compilation of the State Soil Charts for the USSR using satellite photographs.

PUBLISHED IN: Aehrokosm. metody i pochvoved. i ikh ispolzovanie v selskom khozyajstve, Moscow, 1990. pp. 88 to 96.

LANGUAGE: Russian.

AUTHORS: V.L. Andronnikov, L.L. Shishkov, O.M. Tereshenkov, T.V. Ananko, V.D. Vasilevskaya, O.I. Malinin, R.P. Mikhajlova.

ABSTRACT: The selection of material for compiling soil charts, including the State Soil Chart of the USSR on a scale 1:1,000,000, was determined by natural conditions prevailing in the area been mapped (differences in light and dark of the objects to be interpreted, and their geometrical parameters) and by the technical limits of the imaging systems (the resolution of cameras and scanning systems). For compiling the National Soil Charts, the most useful satellite photographs or photographic montages are those on the same scale as the map to be produced or a little larger. Descriptions are given of different types of soil and the indicators used in their interpretation for different areas, and charts are given for the interpretation of soil cover using satellite photographs. The point is made that a significant increase in the reliability of the results of such interpretation is made possible by the use of information gathered by remote means in the multi-band mode (bands 0.6 to 0.7 and 0.8 to 1.1 microns). In the interpretation, use is made of photographic and imaging information recorded at different times of the year and in different spectrum bands. The interpretation of soil cover using satellite photographs proceeds from "general principles to particular instances."

TITLE: The role of satellite mapping in the solution of environmental problems.

PUBLISHED IN: Volgograd. gos. ped. in-t-, Volgograd, 1990, 5 pages. Bibliography: three titles, available from VINITI (The All-Union Institute for Scientific and Technical Information), 15 Jan 1990, no. 247 - V90.

LANGUAGE: Russian.

AUTHOR: G.S. Bobrov.

ABSTRACT: Aerial and satellite techniques for studying the Earth have acquired wide practical applications, including the study of environmental problems. The use of satellite-derived photographs in mapping makes it possible to produce a whole series of charts of

natural phenomena, which can be used for environmental purposes. These charts make it possible to analyse the evolution of the relationship between people and their natural environment.

TITLE: Thematic analysis of radar images of land obtained from the Cosmos-1766 satellite.

PUBLISHED IN: Proceedings of GosNITsIPR (The State Scientific Research Centre for Natural Resources), 1990, issue 36, pp 121-130.

LANGUAGE: Russian

AUTHORS: R.V. Belich.

ABSTRACT: An analysis is given of radar images of land obtained from the Cosmos-1766 satellite, together with terrestrial meteorological data and a surface synoptic chart produced at the same time as the radar measurements. It is demonstrated, that radar measurements can be used for the topographical classification of soils into various soil and vegetation areas, for the study of the dynamic processes underlying soil, snow and ice conditions and for carrying out numerical estimates of reserves of productive moisture in the upper soil layer in the absence of vegetation cover in steppe areas, in areas of transition from forest to steppe, and in deserts.

TITLE: Aerial and satellite mapping techniques in environmental geographical research.

PUBLISHED IN: Sovremennye metody v ehkologicheskom-geographicheskom issled. Documents produced at the Ninth Congress of the Geographical Society of the USSR, Kazan, September 1990. Leningrad, 1990. pp. 116 to 118.

LANGUAGE: Russian.

AUTHORS: A.M. Berlyant

ABSTRACT: This looks as the development of a unified aerial and satellite based mapping system, in particular, the analysis of geo-images. One possible classification is the division of geo-images according to two criteria: that of statics/dynamics, and that of dimensionality (a table is given). Requirements are formulated for the development of aerial and satellite techniques in mapping.

TITLE: The Study of the dynamics of geosystems using space soundings.

PUBLISHED IN: Fundamenty nauki - nar. khozyajstvu, Moscow, 1990, pp. 396 to 399.

LANGUAGE: Russian.

AUTHORS: L.N. Vasilev.

ABSTRACT: As a result of aerial and satellite experiments in the USSR, the GDR, Poland and Cuba, using multi-band images taken from the Salyut-7 and Mir stations and from AN-30 flying laboratories, phase-plane vectors were obtained for the spectral distribution for various crops in the temperate and tropical zones. Investigations are undertaken into the spatial structures of agricultural geosystems in state agriculture (USSR) and in mixed private and state agriculture (Poland). The structural characteristics were studied using multi-band images from the Salyut station, from the Cosmos-1939 satellite, and from Landsat.

TITLE: The environmental information value of satellite-derived imagery.

PUBLISHED IN: Aehrokosmicheskie metody i pochvovedanie i ikh ispolzovanie v s. kh. Moscow, 1990. pp. 61 to 68.

LANGUAGE: Russian.

AUTHORS: E.A. Vostokova.

ABSTRACT: The environmental information value of satellite images is understood as the amount of reliable information on the eco-sphere, ie. on the habitats of living organisms, which can be derived from the interpretation of these images. The basic factors on which the information value depends are described. Environmental conditions are classified in three basic groups: those applying to flora, those applying to animals, and those applying to human beings. Consideration is given to the environmental information value of satellite-derived images in studying plant growth. By combining the topographical interpretation of satellite images with cartographic methods in presenting the results, it is possible to increase the environmental information value of satellite-derived images. Environmental maps can portray the whole range of environmental conditions or simply particular features and characteristics. A map showing topographical indicators can be considered as a comprehensive map, giving the fullest range of environmental information. In addition, satellite-derived imagery can be used to compile specialized maps of eco-systems and of man-made topographic changes. The environmental information content of satellite-derived imagery makes it possible to consider producing a map showing the different ecological areas of the earth.

TITLE: Establishing a data-base for data derived from radar measurements of soil moisture.

PUBLISHED IN: Proceedings of GosNITsIPR (State Scientific Research Centre for the Study of Natural Resources). 1990, Issue 36, pp. 57-61.

LANGUAGE: Russian.

AUTHORS: I.P. Vuzman, V.A. Kapitanov, C.I. Martynov, L.A. Shtanko.

ABSTRACT: Consideration is given to problems in creating a data base for radar measurements of moisture reserves in agricultural areas. A description is given of the structure of the data base and the type of information needed for the development of appropriate techniques.

TITLE: Principles of the environmental interpretation of satellite-derived photographic information.

PUBLISHED IN: Sovremennye metody v ehkologischeskom-geograficheskom issledovanii. Documents produced at the Ninth Congress of the Geographical Society of the USSR, Kazan, September 199[illegible] Leningrad, 1990, pp. 103-104.

LANGUAGE: Russian

AUTHORS: E.A. Vostokova.

ABSTRACT: An exposition is given of the principles of the environmental interpretation of satellite-derived photographic information. The factors determining the environmental information value of satellite-derived information are: the way in which the environmental conditions of the organisms or biocoenoses are reflected; the raw material available (the type of image and the circumstances in which it is produced, the spot resolution, scale, and the nature of the initial processing, etc.). Thematic charts have been produced showing the phyto-ameliorative conditions in the Southern Aral area on a scale of 1:2,000,000, and, on a scale of 1:500,000, the variations in water supply in the Bukharsk area brought about by human activity.

TITLE: The gradient in the frontal surface of the cyclonic meander of the Gulf Stream: an analysis of information from ships and satellites.

PUBLISHED IN: Issledovanie Zemli iz kosmosa. 1990, No. 2, pp. 3-10.

LANGUAGE: Russian

AUTHORS: D.O. Gordejchev, A.S. Kazmin, R. Legkis, K.N. Fyedorov.

ABSTRACT: An investigation into the dependence of the gradient of the frontal surface on the curvature of the front in the cyclonic meander of

the Gulf Stream using data acquired simultaneously in October 1986 from the scientific research ship "Academician Kurchatov" and from the NOAA-9 satellite. It is shown, that in the cyclonic meander, if the frontal component of the speed of the stream remains constant, the gradient of the frontal surface grows with an increase in the curvature of the front, given conditions of cyclostrophic equilibrium. This relationship, however, can be disturbed by various factors, which complicate the dynamic structure of the stream.

TITLE: Aspects of the study of Man-made environmental damage in the Mongolian People's Republic using satellite techniques

PUBLISHED IN: Abstracts of papers given at the All-union conference on "Regional biosphere and ecological research using satellite resources", Zvenigorod, 23-26 April 1990. Moscow, 1990, p. 9.

LANGUAGE: Russian

AUTHORS: P.D. Gunin, E.A. Vostokova, A. Ya. Druk, N.I. Dorofenyuk, Yu. N. Krasnoshchekov, A.V. Prishchepa, P.Z. Radziminskij, E.P. Chernyshev.

ABSTRACT: Research conducted into man-made environmental damage in the Mongolian People's Republic has made it possible to reveal their actual extent, to use satellite images for expert assessment of environmental conditions, and to define fundamental indicators and criteria in eco-system damage. Using satellite images on a scale of 1:1,000,000 and 1:500,000, produced in different years, damage associated with ploughing, deforestation and fires is interpreted.

TITLE: An investigation into aspects of the identification of cloudless conditions using data gathered in the International Satellite Project on Cloud Climatology (ISCCP).

PUBLISHED IN: Proceedings of the State Scientific Research Centre for the study of natural resources (GosTsIPR), 1990, No. 38, pp. 130 to 134.

LANGUAGE: Russian.

AUTHORS: V.A. Golovko.

ABSTRACT: This gives the results of a comparative analysis of data on the identification of cloudless and cloudy conditions, produced using the simple operation algorithm of the International Satellite Project on cloud climatology, and a more complex physical-statistical method based on dynamic cluster analysis. Using these data as a basis, an estimate is made of the efficiency of the ISCCP algorithm, and proposals are made for improving it.

TITLE: Aerial and satellite techniques in soil science and their application in agriculture.

PUBLISHED IN: The collected scientific proceedings of the Institute of Soil Science and Photosynthesis of the Soviet Academy of Sciences, The Scientific Conference on problems in soil science held at the Institute of Soil Science of VASKhNIL (the Lenin All Union Academy of Agricultural Science).

AUTHORS: G.V. Dobrovolskij, V.L. Andronnikov. Moscow, Science, 1990. pp. 247.

ABSTRACT: Consideration is given to the theoretical and methodological aspects of satellite soil research and to the problems of using aerial and satellite information derived from visual instruments in compiling soil maps; to the spectral analysis of soil and crops; and to automated methods for the interpretation and compilation of soil maps. The role played by the remote monitoring of soil and agricultural areas for taking stock of soil and crop conditions, and in the efficient use and protection of the soil layer, is demonstrated.

TITLE: Investigation of glaciers in the Antarctic using radiophysical equipment.

PUBLISHED IN Issledovanie Zemli iz kozmosa. 1990, No. 4, p. 3.

LANGUAGE: Russian.

AUTHORS: V.B. Efimov, V.A. Komyak, A.C. Kurekin, Yu. A. Sinitsyn, A.I. Timchenko.

ABSTRACT: An interpretation is given of the results of radar sounding of antarctic glaciers obtained using side-looking radar equipment on board the COSMOS-1500 and -1602 satellites. A model is given for the dispersion of radio waves by glaciers. Consideration is given to analytical solutions derived for the case of pronounced three-dimensional dispersion in half-space with a random and irregular upper-boundary.

TITLE: Some problems in the environmental monitoring of town planning systems using satellite resources.

PUBLISHED IN: Abstracts of papers given at the All-union Conference on Regional Biosphere and Environmental Research using satellite resources.

LANGUAGE: Russian.

AUTHORS: N.V. Ivanov, Eh. B. Ivanva.

ABSTRACT: The purpose of environmental control in town planning is to achieve a dynamic environmental balance in the optimisation of their territorial and functional parameters. For an overall analysis and environmental monitoring of population centres, satellite-derived images are suggested as a new source of information, corresponding to the current level of science and technology.

TITLE: The use of aerial and satellite photographs in composite mapping.

PUBLISHED IN: Aehrokosm. metody v pochvovedanie i ikh ispolzovanie v s. kh. Moscow, 1990, pp. 16-21.

LANGUAGE: Russian

AUTHORS: Yu. P. Kienko, Yu. G. Kelner.

ABSTRACT: The new composite methods in the study and mapping of natural resources using satellite images is marked by the very close coordination of the cartographic tasks with the processes of acquiring and processing satellite derived information and of studying natural resources and the environment; with the new forms of documentation, special features of technical methods and technology and the organization of work. In recent years, experiments and operational trials have been carried out on the study and mapping, using composite means, of specific areas of the USSR in various natural and economic zones. Consideration is given to the results of work on the composite mapping of the Kalmyk ASSR using satellite derived images.

TITLE: On the extrapolation of geophysical data using aerial and satellite data.

PUBLISHED IN: Issledovanie Zemli iz kosmosa, 1990, no. 3, pp 44-49.

LANGUAGE: Russian.

AUTHORS: A. A. Kirsanov, I. V. Terentev, I. N. Fadeev.

ABSTRACT: In the extrapolation of geophysical fields the use of additional (data) fields is proposed (in addition to the field of terrestrial measurements): the topographic field and the field formed in accordance with plots produced from satellite derived images. To this end, regressive analysis is applied to continuous random fields.

TITLE: Basic methods in the automation of the processing and use of satellite derived information.

PUBLISHED IN: Geod. i kartograf. - 1990, no. 3, pp 23-28.

LANGUAGE: Russian.

AUTHORS: V. V. Kiselev, A. E. Menshikh, M. E. Solomatin.

ABSTRACT: Work on the automation of the processing and use of satellite derived information using digital methods includes the following areas: the development and introduction of effective digital processing technologies; the development of digital means of feeding information into digital mapping systems; setting up and maintaining a data base for satellite derived imagery; and the development and maintenance of Geographical Information Systems (GIS) of different levels and for different purposes. At the State Centre "Nature," several systems have been developed and are functioning successfully, including: "Kosmos" (an automated information-retrieval system for retrieving satellite derived material); "Karta"and "Fotoplan" (information-retrieval systems for specific types of secondary and supplementary documents). Consideration is given to questions connected with the development of an automated information system for use in the management of resource-exploitation and of geographical information systems using satellite derived images.

TITLE: The use of satellite-derived information in the study of regional changes in snow cover in the mountainous eco-systems of Eastern Siberia.

PUBLISHED IN: Opasnye prirodnye yavleniya i chelovek. Moscow State University. Moscow, 1990. pp 166-185.

LANGUAGE: Russian.

AUTHORS: M. N. Laptev, N. I. Lapteva.

ABSTRACT: Using as examples mountainous areas with varying topographic and climatic characteristics, (the Putorana Plateau, the Dzhugzhur Range, the Bureiskij Range), possibilities are demonstrated for using material derived from regular satellite imaging (regional level resolution) using the METEOR Earth-resources satellite in order to investigate the seasonal dynamics of snow cover and to assess the build up of dangerous gradient conditions.

TITLE: Attempt to use satellite images in mapping soil salinization in irrigated areas of Tadzhikistan.

PUBLISHED IN: Abstracts of papers given at the All-Union Conference on "Regional biosphere and environmental research using satellite resources", Zvenigorod, 23-26 April 1990. Moscow, 1990, pp 73.

LANGUAGE: Russian.

AUTHORS: M. V. Lukarskaya, A. T. Martinkus, V. P. Shuklin.

ABSTRACT: For the operational study of saline soil using multi-band satellite images a method has been developed for use in hydrological and land-improvement. During the early autumn, in key sectors, a limited number of soil samples are gathered; at the same time, satellite images of the irrigated areas are obtained. A thematic interpretation of the enlarged multi-band images is then carried out, and the results are plotted on a scale of 1:500,000.

TITLE: Consequences of extensive grazing in Buryatiya, as derived from the interpretation of satellite images.

PUBLISHED IN: Biologicheskie resursy i problemy ehkologii Sibiri: Abstracts of papers given at the 3rd Regional Conference of young scientists in Ulan-Ude, 21-23 March 1990. Ulan-Ude 1990, pp 50-51.

LANGUAGE: Russian.

AUTHORS: A. V. Melnik.

ABSTRACT: Black and white and spectral-band satellite images of areas of Buryatiya are interpreted with a view to assessing pasture growth, to monitoring any changes in its make up, forecasting the productivity of pasture, assessing the accessibility of forage, and monitoring the movement of pasture horses. A system has been developed for the interpretation and identification of pasture land features.

TITLE: Problems connected with the automation of the processing of satellite derived information in assessing land-improvement and water-management parameters.

PUBLISHED IN: Abstracts of papers given at the All-Union Conference on "Regional biosphere and ecological research using satellite resources", Zvenigorod 23-26 April 1990, Moscow 1990. pp 64.

LANGUAGE: Russian.

AUTHORS: A. B. Mironov, E. V. Sukharev, V. P. Shushkin.

ABSTRACT: Consideration is given to a method of processing satellite-derived information for the study of such aspects of the condition of land-improvement and water-resource management features as: salinization of soil on irrigated land, water turbidity, chlorophyll-A concentration, and the clogging of large reservoirs by plant growth. An overall system for processing remotely gathered data comprises: preparation of imagery on an interdisciplinary basis (reduction to a common scale, translation, and imposition of a scale-grid); thematic interpretation; and the production of charts to the required scale.

TITLE: Attempt at using satellite images to locate groundwater leakage in the Chu-Sarysu Depression in Southern Kazakhstan.

PUBLISHED IN Izv. vuzov. Geol. i razvedka. 1990. No. 6, pp 70-75

LANGUAGE: Russian.

AUTHORS: V. I. Nikolaev, G. M. Shor.

ABSTRACT: Using satellite derived images, the structure of the Chu-Sarysu Depression is elucidated, and an analysis is undertaken of the distribution of points at which underground water in mesozoic-caenozoic deposits comes to the surface It is established that these points are linked with areas of fault disturbance. The efficacy of using satellite derived images in solving specific hydrogeological problems is demonstrated.

TITLE: The use of satellite derived images in producing a small-scale soil map of Uzbekistan.

PUBLISHED IN: Aehrokosmicheskie metody v pochvovedanie i ikh ispolzovanie v selskom khozyaystve. Moscow 1990, pp 116-122

LANGUAGE: Russian

AUTHORS: V. G. Popov, A. M. Razakov, V. E. Sektimenko, A. A. Tursunov.

ABSTRACT: The production of a soil map for Uzbekistan using satellite-derived images was based on recommendations concerning the method of interpretation of aerial and satellite images. The purpose of the map is to use satellite derived information to elucidate the fundamental laws of soil-geography, the structure of the soil layer, its evolution and transformation under the influence of Man's economic activity and under natural conditions. Extensive use was made in producing the map of black and white satellite photographs to various scales from the first and second imaging channels and also of synthesised colour images.

TITLE: Satellite mapping of agricultural topographies (as illustrated by Southern Moldavia).

PUBLISHED IN: Otd. geogr. AN MSSR. Kishenev 1990, 45 pages.

LANGUAGE: Russian.

AUTHORS: P. G. Popadiya.

ABSTRACT: A description is given of an attempt at medium-scale mapping of the agricultural topographies in areas of past and current (intensive) exploitation based on the interpretation of high-resolution satellite-derived images. Natural and agricultural systems on a "local" scale were used for the mapping within the topographic area of the Budzhak Steppes in Southern Moldavia. The features needed for interpretation of the man-made background elements in agricultural topographies are shown, and an integrated map is given, with a key, showing the natural and man-made systems in the territory under investigation.

TITLE: The mesostructure of wind fields above thermally non-homogenous surfaces.

PUBLISHED IN: Meteorologiya i gidrologiya. 1990. No. 8, pp 96-100.

LANGUAGE: Russian.

AUTHORS: A. A. Postnov, E. A. Stulov.

ABSTRACT: Experimental data are given for the horizontal wind profile in a surface zone of positive temperature anomaly with an area of 60 X 120 km. Attention is paid above all to the dimensions and the localization of zones where there are wind perturbations, and also of zones of wind stream convergence and divergence. An attempt is made to demonstrate the connection between the amplitude of mesoscale wind perturbations, the speed of the background stream, the vertical extent of "islands of heat", and the contrast between the surface temperature and the vertical temperature gradient in the non-perturbed air.

TITLE: Concerning present day automated thematic processing of satellite-derived high- and medium-resolution visual information in assessing the condition of winter wheat crops.

PUBLISHED IN: Issledovanie Zemli iz kosmosa. 1990. No. 1, pp 103-110.

LANGUAGE: Russian.

AUTHORS: N. V. Sazonov, A. F Molchanova, V. P. Bocharov.

ABSTRACT: Consideration is given to a system for the automated thematic interpretation of medium-resolution visual information using results derived from the classification of high-resolution images obtained at the same time. A brief description is given of a possible classifier using an imprecise (broad) description of classes, and a demonstration is given of the way the elements in each class are connected. Using the example of the processing of images acquired simultaneously from the "Fragment" and "MSU-S" scanners, the efficiency of the system in assessing winter wheat crops is demonstrated.

TITLE: The importance of aerial and satellite geo-information systems in assessing and predicting the ecological condition of major river systems.

PUBLISHED IN: Abstract of papers given at the All-Union Conference on "Regional biosphere and ecological research using satellite resources", Zvenigorod, 23-26 April 1990. Moscow, 1990. pp 50.

LANGUAGE: Russian.

AUTHORS: V. P. Saltankin.

ABSTRACT: Using the results of methodological and experimental research, an analysis is undertaken of the possible uses of aerial and satellite derived information in assessing approximately fifty parameters and characteristics pertaining to reservoirs and cascades. Proposals are put forward for combining aerial and satellite geo-information systems with traditional observations for monitoring major water-resource management systems.

TITLE: The use of satellite derived imagery in studying the environment and natural resources in the Northern Caspian area (Uralsk district).

PUBLISHED IN: Ehkologicheskie problemy Kazakhstana: abstract of papers given at the 3rd Congress of the Kazakh SSR Geographical Society. Alma-Ata 1990. pp 11.

LANGUAGE: Russian.

AUTHORS: N. P. Trufanov.

ABSTRACT: For studying the present condition of natural features in the North Caspian area, use was made of black and white satellite photographs in various bands of the spectrum. The principal processes underlying environmental change are: salination, wind dispersion of light soil, dust storms, general desertification.

TITLE: Software for the inter-disciplinary processing on small computers of data obtained by remote sounding.

PUBLISHED IN: Proceedings of GosNITsIPR (The State Scientific Research Centre for the Study of Natural Resources), 1990. Issue 36, pp 5-18.

LANGUAGE: Russian.

AUTHORS: V. I. Khizhnichenko.

ABSTRACT: Software has been developed for small computer systems for the inter-disciplinary processing of data obtained from remote soundings using KOSMOS-1939. The programmes for this system are capable of a full range of operations, from reception and cataloguing of customer requirements to the issuing of magnetic tapes and photographic images, with associated external data, of specified areas of the Earth's surface. Input data is entered into the processing system on high-density magnetic tapes via the reception and primary input system.

TITLE: High-resolution radar-imaging of the ocean surface using KOSMOS-1870.

PUBLISHED IN: Issledovanie Zemli iz kozmosa. 1990, No. 2, pp 80-90.

LANGUAGE: Russian.

AUTHORS: V. N. Chelomej, G. A. Efremov, K. Ts. Litovchenko, L. B. Neronskij, P. O. Salganik, S. S. Semenov, A. V. Smirnov, V. S. Ehtkin.

ABSTRACT: Results are given of the use in oceanographic research of satellite synthetic-aperture equipment, using a wavelength of 10 cm. Problems of using synthetic aperture radar to show surface and internal waves are discussed. By comparing satellite and ship observations for the Atlantic and Pacific areas, the accuracy of measurements of the line of propagation of wind-sea and wind-swell is estimated to be +/- 20 degrees. It is shown that the modulation of radar signals by wind-sea is greatest when the sounding azimuth is close to the wave vector.

TITLE: The digital processing of aerial and satellite information for use in mapping the soil layer.

PUBLISHED IN: Aehrokosmicheskie metody v pochvovedanie i ikh ispolzovanie v selskom khozyastve. Moscow 1990, pp 214-225.

LANGUAGE: Russian.

AUTHORS: E. V. Shcherbenko, V. V. Asmus, V. L. Andronnikov.

ABSTRACT: A description is given of a system for the digital processing of images, and a method based on this is proposed for producing small-scale (1:1,000,000) and large-scale (1:25,000) maps, and for showing the mesoscale and microscale structure of the soil layer. This is illustrated by the example of the Syrtovyy Trans-Volga area. The system includes the following basic steps: preliminary processing, normalization, preparation of images for thematic processing, thematic processing, formatting and production of the final product. The preliminary processing consists in reducing the imagery to the format on which all the mathematical processing is based. Normalization consists of programmes for filtering out pulse interference, line disturbances, periodic interference, geometrical distortions down to the level of single image elements), for transforming the images into free cartographic projections, and for radiometric correction. The thematic processing is based on statistical methods. The formatting and production of the final product involves the use of editing programmes using sliding-window techniques and techniques for the relaxation and generalization of identification charts. This ensures that the thematic chart will, to a large extent, meet the requirements of the customer. The basic input used was: satellite "MSU-S" images from METEOR satellites, photographs from LANDSAT, images obtained from "KATEh" equipment, aerial photographs on a scale of 1:34,000, field soil charts and other field data. Analysis of the data produced by digital processing has shown that areas of soil in the CHERNOZEM zone can best be distinguished by humus content, physical characteristics, and eroded-soil content. The satellite images show the boundaries of normal, medium-humus, heavy-clay and clay chernozem-soils; areas where normal chernozem-soil and eroded soil are mixed; areas where southern-alkaline chernozem soils are mixed with solonetz soils, and with other chernozem soils.